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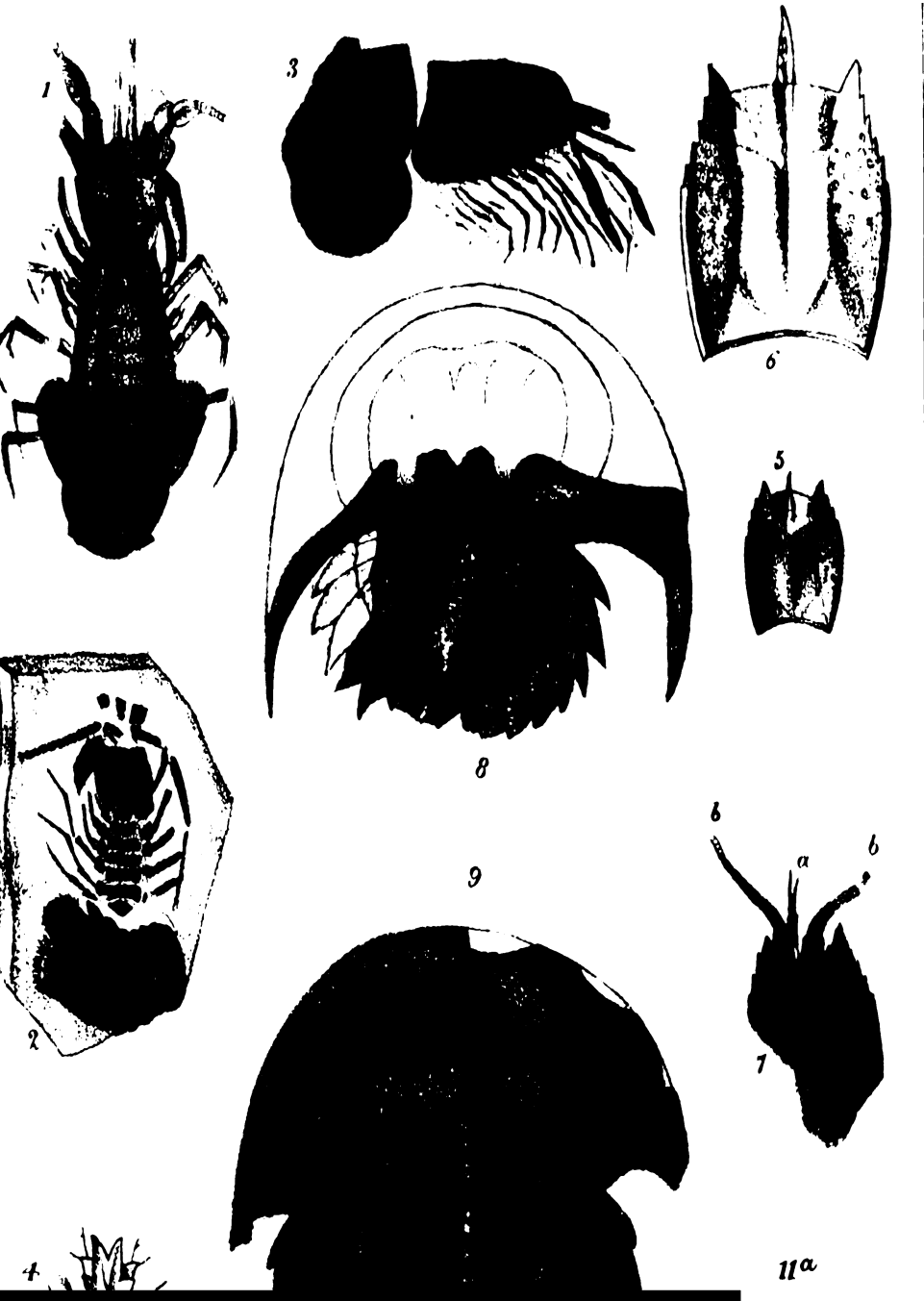

Transactions

Geological Society of Glasgow

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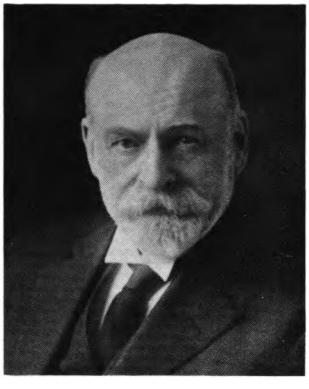

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. II.—PART II.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

SESSION 1865-66.

XLV. *On the Occurrence of* Fossil Trees *imbedded in* Trappean Ash *in* Arran. By Mr. Edward A. Wünsch, Vice-President.

(Read November 9th, 1865.)

Abstract.

The Island of Arran must ever remain classical ground to geologists of all schools, and I am happy to be able to call the attention of students to a new feature in its already numerous attractions, by the discovery of many fossil trees on one of its most romantic stretches of sea-shore.

These fossils occur near the base of the Carboniferous series on the north-eastern shores of Arran, and the beds containing them have hitherto been classified by all geological authorities as trap dykes, or eruptive sheets of trap rock; only the facilities for investigation afforded by a long summer's residence in the neighbourhood, have enabled me to discover their true character. The portion of these beds which I have as yet been able accurately to survey, extends only to about 400 feet along the shore, and in this limited space are comprised no fewer than eleven distinct beds of trappean ash, with numerous sub-divisions of alternate layers of coal, shale, and ash; beds of the same character also extend in both directions along the shore, to probably a thousand feet in thickness. The strata are exposed from a few feet above high-water mark, down to low-water mark (and extend, doubtless,

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to some distance under it), at an angle of about thirty-seven degrees, with the stems of trees imbedded in them at right angles —proving that the stems have retained the original position in which they once grew on a level plain, and that they have been since upheaved on the flanks of the granitic nucleus of the island. As many as twelve to fourteen trunks of trees have been observed on two or three different horizons, and within a very circumscribed area. The height of the trunks is limited by the thickness—about three feet—of the enveloping bed of ash, in which they seem to have been buried suddenly. At the same time, numerous branches must have been broken off, and covered up by the ash around the stems of the trees. These are all beautifully mineralised, and their structure, both internal and external, preserved in a remarkable manner. The large stems seem to consist of *Sigillaria*, with five or six internal piths clearly marked, showing the endogenous structure of the trees. The smaller branches have been identified as belonging to *Sigillaria*, *Halonia*, and *Lepidodendron*, with the exception of one of a new species, as yet undescribed. The structure of the plants points to their having grown in a marsh or estuary, at or below the sea level, and the layers of ashes in which they are buried, must have been showered forth by some neighbouring volcano, either subærial or submarine. The frequent repetition and alternation of these beds indicates a long-continued period of volcanic action, with intervals of repose, during which vegetation flourished, and vegetable matter accumulated—forming thin seams of coal, which had in turn been covered up by fresh showers of ashes, and to which again succeeded a fresh growth of vegetation. At the same time, the land must have been slowly subsiding, as is evidenced by the sedimentary character of the stratified layers of ash overlying each other. The specimens obtained from these beds on such a large scale, and in a perfect state of preservation, will enable the fossil botanist to throw further light on the structure of the plants of the Carboniferous beds, and will afford room for much careful microscopical investigation. Mr. E. W. Binney, F.G.S., of Manchester, who has devoted a lifetime to the study of fossil botany, has kindly undertaken this branch of the subject, and the Society may expect to be favoured with an interesting paper from him in due time.

The annexed diagrams show the alternations of strata and the position in which the trees occur.

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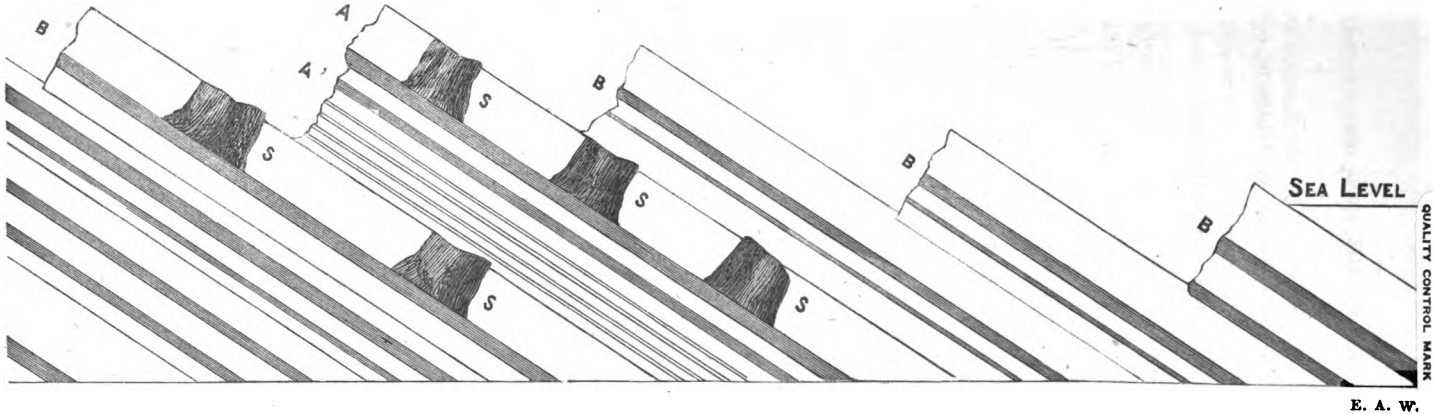
Diagram showing Fossil Stems of Trees imbedded in Trappean Ash in Arran.



S—Fossil Stems imbedded in Trappean Ash, with Roots extending downwards into Shale.
A—Indurated Ash Bed, 3 feet thick, enveloping the Stems S.
A^1—Thin Seams of Coal, Shale, and Ash, in alternate layers; total thickness, 4 feet.
B—Beds similar to A and A^1, with and without Fossil Stems.

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XLVI. *On the* SURFACE GEOLOGY *of* GLASGOW. By Mr. JAMES BENNIE.

(Read December 7th, 1865.)

THE three great divisions into which the superficial deposits of the district in and around Glasgow naturally group themselves,—the period of land ice, represented by the boulder clay; the period of sea deposits, represented by the boreal shell beds; and the recent or human period, represented by the sand and gravel beds, containing canoes—certainly in part, if not wholly, of fresh water origin—are not only better exhibited in this district than anywhere else, but the amount of observation bestowed upon them has rendered this classic region the most typical among the post-tertiary deposits of Scotland.

The peculiarities of the boulder drift early attracted the attention of our local geologists, and were accurately described by them; but, when they tried to account for its origin—having no light to guide them but that of their own experience—they failed completely. The phenomena of the boulder drift was attributed to the action of water, not, of course, in its ordinary action, as they instinctively felt that such action was quite insufficient to account for them, but to some of its extraordinary exceptional effects, such as those occasioned by "earthquake waves," and some imaginary ones,—"waves of translation," as they have been called. Theories such as these, did little good, except to excite discussion, and keep observation alive. During the meeting of the British Association, held at Glasgow, in 1840, a good example of our boulder drift—exposed by the levelling of what was then known as "Bell's Park," was pointed out to Agassiz; and he, being familiar with the various forms of ice-action, from recent study of the glaciers of the Alps, immediately recognised the peculiar striations on the pebbles and boulders as the result of similar agencies, and with characteristic courage declared the boulder clay to be a true deposit of moraine matter. That opinion, as it explained the best understood phenomena of the boulder drift, was accepted by most geologists; but, being carried to extravagance in a theory which supposed the glacial conditions to be universal, instead of restricted to those localities in which the boulder clay existed, it was neglected for some years, and the action of icebergs and coast

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ice called in to account for the phenomena. Of late, however, geological observers have reverted to land ice again, and as many new facts have been discovered which it alone seems capable of explaining completely, this last adoption of it will probably be final.

Shortly before the visit of Agassiz to Glasgow, light broke in unexpectedly from another quarter upon the mystery of the boulder drift, and made its glacial origin probable. The venerable President of this Society, Mr. Smith, of Jordanhill, instituted a series of researches, first on land at Dalmuir, Paisley, Ardincaple, Balnakaillie, in the Kyles of Bute, and other places, during which he extracted from these old sea beds, 190 species of shells, among which were 19 species utterly unknown to local collectors; and, afterwards, to make certain that these might not be yet lurking undiscovered in the neighbouring frith, he searched it thoroughly by a long course of systematic dredging. On comparing the lists of the dead shells from the land, with the living shells from the frith, the remarkable result was elucidated, that a large per-centage of the former were non-existent therein at the present time. These were at first supposed to be extinct species, but Mr. Smith having recognised several as identical with shells from Uddevalla, in Sweden, they were submitted to M. Deshayes, the eminent French conchologist, and recognised by him as living arctic shells; and this clue being followed out, the great fact was established by Mr. Smith, in 1839, that, during the times represented by these shell beds, the climate of Scotland was half arctic in its character, and thus the life of the period bore ample testimony to the teaching of the glacialized pebbles and blocks of the boulder drift.

Of the third or human epoch, characterised by the canoes, little is known geologically; the observers in this field being antiquaries, and not geologists, their attention was absorbed in the canoes, to the neglect of the beds cut through in excavating them. They cannot, therefore, speak with decision, as to whether the water in which the canoes floated was salt or fresh, river or sea. Marine shells indeed were found in one, but being edible species—"whelks and mussels," they might have been shipped as cargo; and their marine character is therefore of no account in settling the question mooted. Of the canoes, as works of art, an excellent description is given by Mr. John Buchanan, in his "Desultory Sketches," published in "Glasgow, Past and Present." From the details given by him, we must conclude that the period was a long one

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during which man advanced from hewing trees into canoes,—little better than simple rafts that could only enable him to float upon water he could not wade through—to building boats as elaborate as herring wherries; and from using only implements of stone, to handling tools that must have been made of iron.

I have considered it necessary to give this rough outline of what has been hitherto known of the surface geology of Glasgow, as it will introduce what additions to it, recent excavations of the surface deposits in and around the city have enabled me to make. But ere I break ground to note what lies underneath, it will be necessary to attend to the form of that ground; as topography often suggests, and indeed sometimes proves, the geology of a district. The inference early drawn from the discovery of the canoes in the ground beneath Glasgow—that its site was once the bottom of a frith or lake-like river of goodly width and depth—is confirmed by the form of the area over which the canoes ranged, which is everywhere decidedly deltoidal in shape; all the low-lying parts of Glasgow being comparatively level as the bed of a lake or river would be; while all the higher parts of the city, those eminences known in local language as "hills and braes," such as Drygate Brae, Balmanno Brae, Garnethill, and Cranstonhill, on the north, and Rutherglen Brae, Langside Hill, and Ibrox Hill, on the south, overlook the lower parts in a way which suggests the idea that they were banks which bounded in this ancient lake or frith. The delta thus indicated in the city, becomes quite apparent in the country above or below Glasgow. If we trace it upwards, we find it converging to an apex at the gorge out of which the Clyde issues beneath Blantyre Priory; and if we trace it downwards, we find it opening out fan-like to near Bowling, which may be considered the bottom of this ancient delta of the Clyde—a goodly one without question, to the formation of which the *debris* of Clydesdale has gone for many hundreds of centuries.

When we examine this old delta lithologically, we find it to be composed of sands, gravels, and clays, in no way differing from what the Clyde deposits in the delta now forming between Greenock and Helensburgh; and we may therefore conclude that the older Clyde, and the country through which it flowed, was in character identical with that of to-day. But if we examine the banks of this old delta, those mound-like hillocks that skirt it on either side, we will find them composed of strange materials—clay over-

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crowded with stones, of shapes as different as their characters are diverse; but all agreeing in certain peculiarities which individualise them beyond all precedent, and make the formation they mark, that unique one known as the "boulder drift." It is very largely developed in Glasgow, all the higher parts of the city being built upon it; yet, as I have little that is new to record, I will not enlarge upon it, but merely state a fact or two which will confirm the theory of its being exclusively a deposit of land ice, or help to fix its position among the beds under consideration. About twenty years ago, Bell's Park—that hillock which Agassiz has made famous in post-tertiary geology—was built upon, and became an integral part of Glasgow, during which operation it was so thoroughly dissected and exposed to observation, that if any remains of shells, or other forms of marine life, had been in it, some trace of them must have been seen in the minute examination to which it was then subjected. None, however, were observed, so far as I could ascertain. On the contrary, a sight was revealed that would have delighted Agassiz, as it gave positive testimony to his theory. The surface of the underlying rock was exposed, and found to be completely glacialised, polished, striated, and even moulded, though somewhat minutely, in the fashion called "roches moutonnées." The direction of the striæ, and the form of the mouldings, proved that the ice had come from the west—the very direction from which the boulders had been judged to have come, from their mineral character agreeing only with rocks situated to the west of Glasgow.

In the "hills," the boulder clay overtops all the other drifts of the delta, and might, therefore, be supposed to overlie them, while in truth, it dips underneath and underlies them all. This was well shown in Tod & M'Gregor's graving dock, at Meadowside, Partick, situated in the middle of the delta. The strata cut through was, first, sand and shingle, equivalent to the river drift, succeeded by a thick bed of brick clay, corresponding to the glacial shelly clay; then a thick bed of muddy silt, which I have now no hesitation in thinking to be the fine white sand that now bulks so largely in the surface geology of the district; and, lastly, the boulder clay, identical in every respect with that of the "hills;" and into it there projected from beneath, a pinnacle, of soft carboniferous sandstone, as if for the purpose of satisfying geologists that the section was complete. Another example of the boulder

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drift occurring under all the surface deposits, is shown at present in the banks of Clyde, at Westthorn, immediately above "Harvie's Dyke," and in the banks of Dalbeth burn. In both cases, the boulder clay is so well marked, as to be unmistakable; and the thick bed of brick clay above it, must be simply the outcrop of the Camlachie clay fields, exposed by denudation.

I come now to the delta itself, and to the recent excavations which have revealed the true geological character of the sand, gravels, and clays, which compose it, and of the conditions under which they were laid down. The principal of these excavations is that of Windmillcroft dock; but ere describing what was shewn there, it will be necessary to epitomise the phenomena of a similar kind which have been observed in other parts of Glasgow, as these will better serve to elucidate the true character of the sections there exhibited, and shew, that, to explain them, it is not sufficient to extend the range of the present river by imagining impossible floods in it, or shiftings of its course, so as to overrun repeatedly the whole space over which the river drift is now found—from Cranstonhill to near Langside Hill—but that we must suppose a river of that width, with a corresponding flow of water down it, though probably of no great depth. These observations, carried on for many years, and extending over the whole area of Glasgow, from Hutchesontown to Whiteinch, Partick, are too numerous to be detailed here minutely in the order in which they were made, but the results of them all, summed up as follows, must suffice :—

First,—The centre of this old delta is occupied by a series of silts, sands, and gravels, so like river *debris* that I can only call them "Clyde drift," meaning thereby that they consist solely of the waste of the country which the Clyde drains, carried down by it, and deposited in its quieter depths, which happened to be then situated where the city now stands. This drift I found to contain great beds of vegetable *debris*, consisting of leaves of trees, sprigs of moss, nut shells, pieces of bark, and wood rounded into pebbles, in fact, everything that could float and be carried by water. This vegetable *debris* had evidently once been the same sort of wrack that we now see carried down by the Clyde in every autumnal spate, and deposited in every quiet nook and corner of its course, there to remain till it sinks through over-saturation, and is covered up by the next precipitation of sediment that occurs.

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These beds of sands and gravels extend from five to fifteen feet in depth, varying greatly in short distances, showing that the surface of the lake or frith bottom had many hollows in it, scooped out, most probably, by the water that carried the gravel. At the foot of the gravel bed a layer of large pebbles, broken boulders, and odd-shaped pieces of stone, invariably occurred, the origin of which has cost me many a thought, but I could never hit upon a satisfactory solution, and the puzzle is a puzzle still.

Second,—Below these sands and gravels, a bed of a very peculiar sand shewed itself in several foundations for stores in Robertson Street and James Watt Street, at the General Terminus Railway, and at the excavations for Mavisbank Quay. It was, when dry, white, soft, and almost impalpable to the touch, singularly free from grit or gravel, indeed, often totally free, and rarely marked by lamination, ripple mark, or false-bedding. The contrast between it and the gravel above was striking, and never failed to suggest a very diverse origin to that of the rough ochrey gravel lying immediately above it. I instinctively styled it "sea sand," as it seemed to me that only "in the stillness of some central sea" could such sand sink; and I explained the abrupt change from it to the rough gravel, by supposing, that an upheaval had taken place, in the interval between them, by which the sea bottom had been lifted up from a region of quiet deposition by gravitation, to a region where currents, tides, and waves prevail. Whatever may have been the cause, the change is remarkable, and arrests the eye and fascinates the mind at once.

Third,—In many places excavated for sewers,—especially in the eastern parts of the city, a thick bed of firm, compact clay was frequently exposed. It was always highly laminated, and often, nearest the surface, full of decaying roots or stems of water plants, which were evidently *in situ* and had lived and died in the clay. In neither of these three deposits did I find, at that time, any shells or other signs of life that could enable me to settle the character of the water that deposited them. I did not, however, conclude that no life had ever been there, but imagined that, during the long period since this old delta had been elevated into dry land, the rain water, penetrating freely through the loose sand and open gravels, had wasted away the shells once lodged in them, and made them only *apparently* azoic, a guess which subsequent discoveries have shown to be very near the truth.

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I now come to the excavation of Windmillcroft dock, the strata exposed therein, and the discovery of shells in it, which have at length told us in the unmistakable language of Palæontology the true character of these sands, gravels, and clays, and reduced them to such orderly sequence that we can now read their history with ease. The excavation was divided into two periods—the first, undertaken by the Clyde Trustees themselves, some seven or eight years ago, during which the western half of the dock was only half dug out, when it was stopped by a temporary fit of economy on the part of the Trustees elected under their new constitution; the second excavation was commenced by the contractor for the dock last year, and is now almost completed. During both periods, delighted with such a favourable opportunity of studying systematically the strata I had so long explored at random, I attended almost daily upon the progress of the diggers, and watched everything turned out. The sections exposed during the first excavation were not deep, only ten or twelve feet deep at most, but they revealed the two strata of river drift and sea sand, as shewn in excavations in other parts of the town. The beds of vegetable *debris*, also, were identical in appearance, but more determined in character than in other places, many large oak trees occurring amongst them. The dimensions of one may be noted. It was sixteen or eighteen feet in length by three and a-half feet in diameter, and had been stripped of its bark by water action; it was rotten on the outside, but quite sound at the heart, and had evidently been long knocking about as a "drift log" in the old estuary ere it had sank in its waters. As a whole fleet of canoes had been found in excavating for Springfield Quay, adjoining Windmillcroft, I expected that, during the excavation of it, some might be found there also, and the ambition of my heart satisfied by assisting at the discovery of a canoe. None, however, were discovered—all my wishing, waiting, and watching, failing to bring one to light. However, it was not all in vain, as I had the happiness to find several articles which must have belonged to the old canoemen, and been used by them in the daily economy of their life. I looked anxiously for shells, bones, or any evidence which might characterise the water as salt or fresh, but saw none sufficient to determine that point. Once, however, I saw the shadow of a shell, the epidermis and cast of it in the sand, but supposing it to be that of the common edible mussel, which some

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old canoeman might have chucked overboard, after baiting his line, I failed, then, to realise the fact which I had in my very grasp.

Ere I describe any of the sections in Windmillcroft, I may note the dimensions of the space at present excavated, and the solid contents taken out, in order that those who have not visited the dock may form some idea of its extent, and realise for themselves how good a sample of the old delta of the Clyde, and of the bottom of the sea that preceded it, I had the good fortune to examine and draw my conclusions from. Length of excavation, eleven hundred and fifty feet; breadth, two hundred and seventy feet; depth from the original surface, twenty-two feet, which gives upwards of six and a half millions of cubic feet of soil removed. There is still fourteen feet in depth to be excavated, but as that is to be done by dredging machines, the same facilities for observation will not recur; but it matters less, now that we know the probable character of the beds the dredge will traverse.

As the sections varied much, I must describe two at least, taking first, that beginning at the foot of West Street and running westward, as it holds the key to all the rest, by containing the clay with boreal shells in it, and therefore the most typical of them all. In this section there occurs, under the surface, rubbish and vegetable mould, say two feet, succeeded by a soft red sand three feet thick; next, a bed of open gravel, having but little sand intermixed with it, four feet thick; then a bed of clay, similar in every respect to our common brick clay. This was cut through to a thickness of eleven or twelve feet, but it goes several feet farther down. Beneath this clay the white sand must lie, because at a little distance from the face of this section the clay thins considerably, and the white sand crops out from under it. At the distance of forty or fifty yards from the foot of West Street, the bed of clay ends abruptly, being cut off by denudation, after thinning out to only four or five feet in thickness. The upper bed of gravel lay in the hollow, and took the place once occupied by the clay, so that in the section, after that, there was seen soil, two feet; soft red sand, three feet; gravel, with much sand now mixed with it, seven or eight feet; white sand, five or six feet. But these thicknesses are not persistent for any great distance, the white sand sometimes disappearing out of the section altogether, and the river drift, in the form of rough sand or grit or vegetable *debris*, extending to

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the bottom of the excavation, a depth of twenty-two feet. This, however, is exceptional, it being evident that a hollow had been scooped out by denudation in the clay and white sand, into which hollow the river sand and gravel had been drifted—a fact worth recording, as absolute depth is on that account no safe guide, and cannot be depended on in such circumstances. The significance of this caution will be seen hereafter, when we try to fix the age of the causes.

The sands, pebbles, and broken boulders, but, above all, the large slabs of splint coal, testify as to the rocks from which they had been derived—the upper coal measures, which the river traverses before it reaches Glasgow; but, from many circumstances, I have come to the conclusion, that very little of this drift had been derived directly from these rocks, it being essentially a re-deposit from the boulder clay and other glacial drifts in the upper wards of Clydesdale. Many facts proved this: not a few of the pebbles had the hunchback form common to glacial pebbles, and some were still partially marked with striæ—a good sized boulder of boulder clay once turned up, and at another time a patch of it, so large, that it looked like an outlier of that formation still *in situ*. From both, pebbles were obtained, as intensely glacialized as any from the "hills" of old boulder clay round Glasgow. Pebbles of the brick clay, that lay beneath or rather just beyond the land, occurred in it not unfrequently. Rounded bits of peat moss, and fragments of those pipe-like incrustations that are formed round roots and stems of plants, showed that the river had not spared its own banks in former times. Everything about this drift testified that it had been swept down by a great river like the Clyde, draining a country such as Clydesdale is now. Like all others, this portion of the river drift had its beds of vegetable *debris* in all the various forms—leaf beds, drift peat, water-worn twigs, and nut shells. Space will not permit a description of these beds in detail, even if I were botanist enough for the task, but I think a good service might be rendered to science if some botanist zealous enough were to make a special study of these old leaf beds of the Clyde—representing, as they do, the old flora of Clydesdale—and give us a good monograph on the subject; not only would he earn fame for himself, but he would make the present flora of Clydesdale better understood than it has yet been. In proof of this, I may state, that no beech nuts or leaves have been found in these old

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leaf beds; and, as the nuts and leaves of the beech form the most abundant constituent of the Clyde wrack of the present time, a great change in the flora must have occurred.

I will now describe the discovery of shells in this old drift, which proved it a river drift indeed. This section faces the south, and being exposed directly to the full force of the sun and the wind, suffers the utmost amount of denudation they can conjointly effect. As the sand falls or is blown away, the pebbles are brought into strong relief, and can be inspected with ease. I examined them frequently in the hope of finding a cinder or "ghaist" among them, to prove that the canoemen knew so much of the fragments of splint or common coal they saw among the gravel, as to make fires of them. While thus engaged, one windy day, I noticed something fluttering among the pebbles, and soon realised the nature of it, as a shred of the epidermis of the common fresh water mussel (*Unio margaritifera*, Linn.), so frequently found in the Clyde at the present day. Knowing the geological significance of the fact, I commenced a strict search for more, and soon ascertained that they occurred abundantly in the gravel. After a very windy day, I have found next morning as many as five, and for some time, I did not fail to find one daily. Altogether, I have found sixty-seven of those shell skins—a number sufficient to characterise the water that deposited this drift as fresh water, as much so, indeed, as that of the Clyde anywhere above Glasgow. A few of them had belonged to single valves, and in one or two instances, the epidermis of both valves was flattened together; but the greater number were lying in their natural position, with the umbonal portion undermost, proving that they had lived and died in the gravel, and had not been drifted down by a spate. Not a vestige of the shell remained, in any instance, attached to the epidermis, the shelly matter having been dissolved by the action of rain water percolating through the soil. Indeed, in all of them, only the thicker parts round the lip of the shell were preserved. I may remark, finally, that if strong shells like these *Unios* suffered so much, more fragile fresh water shells have little chance of escaping destruction; and it is vain to hope for them.

The next division of the section is the great bed of clay. It must be sixteen or eighteen feet thick, and, for most of that thickness, very pure—little sand being mixed with it. Very few stones are in it, and none of them large; in form, they resembled

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glacial pebbles. One, a piece of a broken boulder, was distinctly striated; so there can be little doubt that this was a true glacial clay washed out of the old boulder clay and re-deposited, while the glacial condition still existed in Scotland. This was confirmed by the shells that occurred in it. They were not numerous either in species or individuals; indeed, I have gathered more at Paisley, in a single day, than I have got in a whole year from Windmill-croft. It will be seen from the list of these shells, and the accompanying note appended to this paper—for which I am indebted to the Rev. H. W. Crosskey—that he has recognised several distinctive glacial species among them, such as *Tellina calcarea* (proxima), *Leda pernula*, and *Leda pygmæa*. The sea, therefore, in which this clay was deposited, must have possessed (in a modified degree, of course), the same glacial character as that which formed the great boreal shell bed at Paisley, and elsewhere throughout the lower parts of the basin of the Clyde—a very important fact, as it introduces order among the great masses of clay and sand forming the old delta of the Clyde, and reveals to us better than hitherto, under what diverse conditions it was formed.

The next member of the series—the white sand, seems to me the greatest of them all in thickness and extent. From the irregular manner denudation has acted upon it, it is difficult at first sight to realise its total depth; and it is only after some consideration that one is prepared to admit it to be so great as it is. In some parts, it approaches within five or six feet of the surface; while in dredging between the piles at the entrance of the dock, they have gone down nineteen feet without exhausting it. This gives it a depth of more than thirty feet; the present depth of the dock being twenty-two feet. I have been told that in the boring for the Union Railway bridge across the Clyde, a depth of eighty feet was reached without passing through it; and I have seen it lately in the lands of Barrowfield, forming a thick bed twelve feet and more, below a bed of well-marked river drift, twenty feet in depth. From these, and many other facts of a like import, I have little doubt that it extends over the whole area of Glasgow. Now, when we consider the peculiarities of this sand, so soft, so fine, so free from grit or pebble, and consider the process of its formation, we must prepare our minds to conceive of the period of its deposition as one of great duration; and the work of reducing ordinary sandstone, not to speak of crystalline

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quartz, as almost infinitely great, and only to be equalled by the great time or agencies occupied in forming a like thickness of glacial clay. I have sometimes thought, while considering its place here, its colour and general appearance, so like the sand that remains after washing the glacial clay for shells, that it is a re-deposit, and is but the sand of the boulder clay washed out of it and reformed again; as the brick clay is undoubtedly the clay of the boulder drift so sifted and assorted. But whether this is a fact or not, I have no doubt that it is a member of the glacial series, and must be reckoned among them when they are summed up as a whole. This was proved not only by its underlying the clay with the glacial shells, but also by what was lately found in itself, namely, about a score of boulders of the regular form and character; one large limestone block being as emphatically polished and striated as any in the old boulder clay of Bell's Park or Cranstonhill.

So far as shells can testify of life, it is a perfect blank; not a vestige of any having appeared in all my many years' acquaintance with it; neither have I seen any signs of vegetable life. Indeed, it seems perfectly *azoic*; and I am only prevented from finally concluding it to be totally void of life, by the thought, that in some almost miraculous manner, remains of life may yet be found here preserved in it; my experience of the Clyde drift and the glacial clay teaching me never to despair of finding life in any likely place whatever.

Perhaps it may help to make the sections just described more intelligible, if I note the relations which I conceive to exist between the various beds of which they consist. The white sand and the clay which evidently lay in a hollow in it, must be considered as one geological formation; or, perhaps, it will express better the circumstances of the case to say, that the deposition of the clay was but an episode in the formation of the great bed of white sand which lies below and above it. The clay, where thickest, is very pure, and free from admixture with sand; but as it thins out towards its edges, it becomes frequently interstratified with the sand—many alternations of the one with the other occurring in very short distances. I have seen reason to believe that these thin beds of clay and sand were of later date, though lying in the same plane as the great bed of clay. They are very level, indeed apparently quite horizontal; while the thick bed of clay shews

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signs of disturbance so palpably, that even the workmen noticed it, and spoke openly of it as troubled or distempered. The laminations dip always at a very high angle, and dykes of fine sand run through the clay from top to bottom, somewhat after the manner of trap dykes in carboniferous sandstone and shale. Further, I have lately detected roots of plants in these thin beds of clay and sand, which indicate brackish, if not fresh water conditions, as the plants, I am told, are not sea weeds, but probably *Equisetaceæ*. These roots extend sometimes two or three feet, with no appearance of beginning or end, and little change of diameter. I suppose them to belong to the period of these thin beds, and not to that of the river gravel that lies immediately above, because, among other reasons, they seem always to stop short of it; and, besides, the gravel indicates running water, and plants having such habits as the *Equisetaceæ* could not live in it.

The change from the marine beds—the white sand, the clay, and the thin beds—to the undoubted river sands and gravels, is always abrupt and sharply defined, proving that they are unconformable to each other, and indicating the occurrence of some secular change, such as an upheaval having taken place in the interval. That change must have been accompanied by much denudation, as vestiges of beds which must have lain upon the clay, occurred here and there; and the surface of the white sand was always irregular, large hollows being frequent in it. It is difficult to estimate time by a denudation, the amount of which is uncertain; but, assuredly, it warrants the conclusion that the break in the succession represents a space of time during which many changes must have taken place—the peopling of Clydesdale by man being, perhaps, the chief.

Having exhausted the sections at Windmillcroft, I may now inquire what lies beneath. To this the answer must be, that, judging from what I remember seeing in Meadowside Dock, Partick, and of what I have been told occurred in building the quay at the General Terminus Railway, viz., that they came upon the boulder clay there, and laid the foundation of the quay wall, some eighteen feet deep, in it, it is probable that the white sand, after extending downwards for several feet farther than the dredge reached, finally gives place to the boulder drift, and that again to the rocks of the Carboniferous system—and thereby ends in Windmillcroft the surface geology of Glasgow. This, of course, is a

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guess, but it is probable enough to be the truth, and we will take it as such, as it closes fitly our history. All the glacial proclivities of the beds we have passed through, culminating naturally in the most glacial of them all—the old boulder clay, which all who have studied it most judge to be, without question, veritable moraine matter—the memorial and the monument of the last great ice age of the world.

Let us run rapidly through the changes which have taken place in and around Glasgow since that time. First, then, we have lowermost the boulder clay, which overtops in our Glasgow "hills" all this series of beds, yet in our docks underlies them all. It speaks of a land of ice, whose mountains were of aged snow so deep that the everlasting snow of the Alps can never equal it, and whose rivers were glaciers hundreds, if not thousands, of feet deep, the drift wrack of which is this boulder clay itself. Then we have the white sand, representing a time of quiet marine deposition, when a sea of a somewhat glacial character overspread all the lowlands round Glasgow, into which this almost impalpable sand flowed and settled quietly down, burying up nothing but a few boulders that the "ships of ice" dropped as they sailed over the surface far above. Then we have the sea of the glacial clay, when a few shellfish found here at Glasgow but scanty nourishment from its muddy waters. Then we have a great change. We have no more sea here in Clydesdale, but, instead, a great river, shallow, it may be, but broad, with the shells, whose skeletonised skins are before us, living, then, abundantly in its waters,—and we have the old canoeman of the Clyde slowly paddling his clumsy boat till he reaches his favourite fishing station here at Windmillcroft, where he anchors his canoe with a stone—this very one, it may be—and then drops his net or his line with, perhaps, one of these perforated stones as a sinker, and tries—not in vain, let us hope—to find his daily bread in the waters of the great river we now see but in its sands. All these pass away, and we have the little Clyde we know, with its Broomielaw and its Windmillcroft Dock, and beyond them the great City of Glasgow, that reckons its ships by thousands, traversing all seas, and making Clyde-built ships famous all over the world. A great change this from the log canoe—to which a voyage across the Clyde, of its time, was, perhaps, a day's sail—to the Cunard steamer, like the Clyde-built "China," that can cross the Atlantic

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in a week. Yet let us be just to the old Glasgow canoeman. He and men like him taught the world the elements of navigation—that wood could swim and paddles propel, and without the Clyde canoe the Clyde steam-ship might not have been.

List of perforated and grooved stones found in the river drift at Windmillcroft, and supposed to have been used by the canoemen as sinkers for their fishing lines, or nets, or other purposes of their craft:—

No. 1.—Circlet of splint coal—diameter, 3½ inches; thickness, 1½ inch; width of perforation, 1½ inch; weight, 6½ oz.; neatly made. As much labour must have been bestowed in making it almost perfectly circular, it is doubtful whether it was used as a sinker.

No. 2.—Circlet of bituminous shale—diameter, 5½ inches; thickness, 1½ inch; width of perforation, 1½ inch—the sides of the perforation are much bevelled; weight, 16½ oz.; rudely made. As it is much worn, it had probably been long used ere lost.

No. 3.—Oblong square of bituminous shale—longest diameter, 7 inches; shortest, 4½ inches; thickness, 1 inch; width of perforation, 2 inches—sides of perforation slightly bevelled; weight, 14 oz.; rudely made.

No. 4.—Oblong pebble of grey-wacke. As the edges are well rounded, it must have undergone much water wear ere pressed into the service of man. Longest diameter, 5½ inches; shortest, 3½ inches; width of perforation, ½ inch. Sides of perforation slightly bevelled, but they are very irregular, as the stone is very tough in texture, and must have been difficult to cut through. The workman, after having cut it about half through, must have turned the stone and commenced on the other side, and continued till he had completed the perforation. Weight, 14½ oz.

No. 5.—Circlet of iron—diameter, 1¾ inch; thickness, ¾ inch; width of perforation, ¼ inch; neatly made. The workman who made this sinker must have been an adept in handling metals. Weight, 8 oz.

No. 6.—An old glacial pebble of greenstone of the regular hunchback form—longest diameter, 2¾ inches; shortest, 2¼ inches; thickness, 1½ inch; grooved all round in the direction of its longest diameter—depth and width of groove, ⅛ inch; weight, 8 oz.

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No. 7.—Oblong square block of sandstone—probably an old glacial boulder—length, 14 inches; breadth, 10 inches; thickness, 7 inches; grooved all round, deeply at the corners, but slightly on the sides; greatest width of groove, 2¾ inches; greatest depth, 2 inches; weight, 58 lbs. This stone, I suppose, might have been used as an anchor to one of the smaller canoes.

Note.—All these articles were obtained from the gravel bed, so emphatically proved by the epidermis of the *Unios* to be river drift, and the depth at which they occurred did not exceed 15 feet. Along with the circlet of iron (No. 5 of the list), I found an implement made of wood, bent somewhat in the form of the letter *S*. The upper part had been used as a handle, as it was hollowed out to fit the hand so as to give it a better grasp; the lower part was more sharply bent, and had been used to hook things by, and the impression of a string was distinctly visible at the acutest corner of the angle. I also found several pieces of wood not unlike, in shape, a boy's bat. The handles were always very short, just enough to grasp by. These, I supposed, might have been rude paddles, but they must have been very ineffective, as the person using them must have bent over the side of the boat ere he could touch the water with them. I found also a well rounded and otherwise water-worn pebble of burnt shale, which had evidently been a "ghaist" or cinder once in an artificial fire.

XLVII. *Note on the* Fossils *collected by* Mr. James Bennie *at* Windmillcroft. By the Rev. H. W. Crosskey, Vice-President.

The fossils of the glacial bed of the Clyde are generally so abundant, that the occurrence of a clay through which they are very sparingly scattered, in itself becomes significant. During the glacial epoch, it would appear that the fauna of the sea was distributed according to the usual laws, and not by any exceptional catastrophes. Each kind of sea bottom had its own specialities; the finer and coarser muds, and the sandy, in their various admixtures, had severally their own characteristically abundant species, exactly as the naturalist finds to be the case in the frith, at the present day. The action of different currents and inflowings

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of fresh water would give conditions, multiplying or decreasing a particular species. It is to be expected, therefore, that fossils should not be equally abundant in all the beds. The Windmillcroft clay, so well explored by Mr. Bennie, seems to have been deposited under conditions less favourable to life than the Paisley beds. The sand which forms its base has no representative in the Paisley sections. The clay must have been washed out upon the sand from the neighbouring accumulations of old boulder drift.

I am disposed, moreover, to refer the clays at Windmillcroft to a comparatively recent period of the glacial epoch. They probably succeeded the uprise of Jordanhill and Airdrie. This I think probable for several reasons:—(1.) They rest on one of the series of hollows connected with those denudations which have given the district its present aspect. (2.) The succession of deposits, from marine to fresh water, does not appear to have any break of the character which must have been caused by the uplifting of Jordanhill. I submit this question for further consideration; but, if this determination of age be correct, the Windmillcroft clay belongs to the closing of the glacial epoch, when the land was rising, and the boundaries of the district through which the Clyde now flows, were gradually being more definitely marked out. Under these circumstances, the water would be becoming more shallow and less salt; and the clay which it was washing and re-depositing, would not furnish a favourable habitat for the very arctic and comparatively deep sea forms of the older glacial beds. Such forms would be found to linger, but not to abound.

It is to be hoped that further excavations may enable us to trace the oscillations of level which have occurred throughout Clydesdale. The valley of the Clyde may have possibly been the bed of a river, then of a sea, and then of a river again. At Stirling, a bed of peat is said to underlie the marine clay; and if there were sea at Stirling, it would flow over Clydesdale. There are traces, also, of a slightly warmer fauna, intervening between the arctic fauna of the glacial epoch, and the fauna of our present waters. Oscillations of climate accompanied oscillations of level. Doubtless, also, there have been changes of vegetation; and the leaf beds of the silt of Clydesdale need more accurate study.

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The specimens submitted by Mr. Bennie belong to the following species:—

MOLLUSCA.

Tellina calcarea *(proxima)*.	Leda pygmæa.
Mya truncata.	Skenea planorbis.
Leda pernula.	Littorina litorea.

CIRRHIPEDIA.

Balanus balanoides.

ENTOMOSTRACA.

Jonesia contorta.	Cythere latissima.

FORAMINIFERA.

Nonionina striato-punctata.	Quinqueloculina seminulum.

XLVIII. *On the* AURIFEROUS ROCKS *and* DRIFTS *of* VICTORIA. By Mr. WILLIAM CAMERON.

(Read January 11th, 1866.)

IN submitting to the Geological Society of Glasgow an account of the auriferous rocks and drifts of Victoria, I have to state at the outset that my opportunities of making myself practically acquainted with the peculiar habits of the precious metal, whether as developed in auriferous rocks or in alluvial deposits, have been both varied and extensive, and the statements of the following paper are nearly all the result of personal observation. Where I have departed from this rule, I have confined myself to the most reliable authorities, and I have to acknowledge my indebtedness for much information to Messrs. Geo. F. Ulrich and D'Oyley H. Aplin, of the Geological Survey of Victoria.

In the principal gold fields of Victoria, the rocks consist chiefly of thick bedded, fine grained sandstones, interstratified with belts of slate of Lower Silurian age. In the lower ranges the sandstones are generally soft and of a yellowish colour, interstratified with soft whitish argillaceous slates, whilst in the higher ranges, hard bluish-grey sandstones prevail. The slates are also indurated and of a darkish blue, and, in some localities, are admirably adapted for roofing purposes. In the Lower Silurian rocks of the gold-fields, fossils are not generally plentiful, although, in some belts of slate, Graptolites and Hymenocaris have been found in abundance. The

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strike of these rocks is generally within a few degrees of north and south, and the prevailing dip is towards the west. The latter, however, varies much more than the former; the bedding and cleavage planes are often identical. Quartz reefs are very abundantly interspersed, and are nearly all more or less auriferous; the strike of these generally corresponds with that of the surrounding rocks, and cross lodes are rarely met with; and in this respect, I am informed, the mines of Victoria afford a contrast to those of Europe; the metamorphic slates are generally of a greenish grey colour, with a glossy striated surface full of greenish fahlunitic grains, and frequently valuable for quarrying purposes, splitting up into large regular slabs, which have been much used for paving.

In nearly all the Australian gold-fields, granite is to be found uptilting the Silurian rocks; the most prominent mass in the western gold districts is that extending between Mounts Macedon and Alexander, both prominent granite mountains, and trending west from these lie some of the principal gold fields. The granite of these ranges is generally of a coarse grain, and of a greyish white. Of its component parts, white or grey orthoclase is the most prominently developed, imparting to it frequently a porphyritic appearance; in some places, small crystals of black hornblende are found, and also small veins of quartz and red felspar. Along the ridges of the valleys the granite is harder and finer grained, and appears in large round masses. In the neighbourhood of Mount Alexander, some valuable quarries have been opened, and about twelve months ago a magnificent block, weighing over forty tons, was conveyed from thence to Melbourne by rail, for the monument of Burke and Wills, the explorers.

The auriferous drifts lie in the Older Pliocene, Newer Pliocene, and Post-Pliocene. The Older Pliocene exists generally in the form of cement-hills, extending along the banks of the water-courses or creeks; these hills consist of bands of conglomerate, round quartz and sandstone boulders and pebbles, firmly cemented together by hydrous oxide of iron, or decomposed felspar, and where these have occurred in successive layers there are frequently found distinct deposits of gold in each layer, hence what were called false bottoms often perplexed and deceived the early diggers. I have known some hills where these ferruginous cements were as much as twenty to thirty feet in thickness, and of a dense brown and almost bituminous appearance. These cements, besides presenting on their upper

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surface, bottoms, whereon deposits of gold were left, often contain imbedded in them a considerable quantity of waterworn gold, the only way of extracting which is to crush the cement and subject it to the same treatment as quartz. I have crushed cement which yielded twenty ounces to the ton, the gold existing in flat pieces about the size of peas and beans, rounded at the edges. These cements are so hard and compact that they can only be mined with the aid of blasting powder. These hills generally overlie basin-like depressions in the Silurian rocks.

Round the flanks of the older hills lie deposits of Newer Pliocene, also highly auriferous, frequently containing large heavy nuggets. The Post-Pliocene deposits occupy the gullies and upper beds of the creeks. They consist of fragments of shale, sandstone, and angular quartz. In the creeks or in beds of deep valleys are found deposits of Newer Pliocene, covered by re-deposits of Post-Pliocene, and where this occurs there are deep sinkings. These drifts, fed in the first instance by tributary gullies, frequently extend for miles, and assume the character of river-beds, with well-defined banks and large rounded quartz boulders, the results of powerful aqueous action. When these contain gold they are called "leads." In some districts they are very rich, and from the great width and depth of their deposits, afford ample scope for the most extensive mining operations.

In regions where volcanic overflows have taken place, we find these drifts often overlapped by one or more layers of trap rock, as in the Coliban, Loddon, and Ballarat districts; in the latter, more especially, this has occurred. Here, beginning at the slopes of the Silurian ranges, the course of the gold may be traced, first appearing in shallow rifts and gullies, where the alluvial deposit varies in depth from six inches to as many feet. Further on we come to better defined veins or runs, where the sinking varies from twenty to fifty feet; these, in their turn, merge into deep leads, eighty to one hundred and twenty feet from the surface, assuming, as in the deeper deposits, a more defined character, until they disappear under a broad overlying belt of trap. Underneath these overflows of trap there are auriferous deposits of great breadth and thickness.

In this district the lodes appear to be much better defined than in any of the other gold fields, the slates and schists rising in abrupt ridges along their course, and thus more completely directing and

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confining the run of the leads. Some idea of the wealth of the Ballarat mines may be formed from the fact that the mining reports show that eight of the principal deep lead companies of this district obtained in the aggregate nearly 12,000 ounces of gold during the month ending 21st October, 1865.*

On the banks of the Loddon and the Coliban, the trap overlies the Pliocene hills, and the rivers having worn their way down to the schists, leave along their banks an escarpment, shewing the whole series, basalt, drift, and Silurian rocks, and where this occurs, the plan of tunnelling is found to be a most efficacious and economical method of working. These are frequently covered by a deposit of angular quartz drift.

Of other alluvial mineral deposits besides those of gold, tin alone exists in any notable quantity, and it is chiefly in the Ovens district (the great eastern gold field of Victoria) that this occurs. It is found here in the form of black sand, which contains from sixty to seventy per cent. of pure tin, as also a small per centage of gold.

Diamonds, rubies, zircons, sapphires, and topazes have been found in the various drifts throughout the gold-fields, but from the ignorance and carelessness of the miners, many of these are thrown amongst the refuse, and none of any great size or value have as yet been discovered.

But gold, as found in the matrix, is far more interesting to the geologist, than as it is seen in alluvial deposits. The latter is governed by laws which are patent to all, and are, with slight variations, alike in all parts of the world where gold is to be found. Whilst of gold in the matrix comparatively little is known, every new fact brought to light in connection with operations in auriferous rocks, widens the field of speculation; and, by extending knowledge in reference to what has now become an important branch of industry, must have a practical and beneficial effect.

There can be little doubt that in Victoria, quartz, if not invariably, is, at least, generally the matrix in which gold is to be found. I have been told that it has been seen in granites, slates, and sandstones; but I have never known one instance of this, except when these rocks have been in close contact with, or have intruded upon, an auriferous quartz reef. I have frequently seen

* A recent return from one of the Victorian gold fields, mentions that 2400 tons of cement, from one mine, yielded 2800 ounces of gold.

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the "mullock," or slaty casing, which faces nearly all quartz reefs, containing gold; and, in some cases, I have known the gold to run out of the quartz into the casing, and back again into the quartz; but this casing or mullock is always much broken up, and interlaced by numerous minute veins of quartz. I have also known granite, which has intruded into a quartz reef, to contain gold; but I have never seen a single instance of gold in slate, sandstone, or granite, apart from some quartz lode. My experience, therefore, leads me to infer that here the true matrix of gold is quartz; and, that when gold exists in other rocks, it is only when these are associated with quartz.

Mr. D. Forbes, in a paper read before the British Association, describing the gold-bearing rocks of South America, refers the introduction of gold into the upper crust of the globe, to two distinct formations of granite; and mentions the occurrence of gold washings amongst granite decomposed *in situ*. I have known no instances of this in Victoria.

Amongst the minerals found in the quartz reefs of Victoria, there are, besides gold—silver, iron, antimony, galena, copper, iron and arsenical pyrites, and sulphurets of lead and zinc.

Silver has been found to any extent only in the district of St. Arnaud, which lies near the base of a range of hills known as the Pyrenees. It exists in the form of a chloro-bromide of silver generally lying secreted in ferruginous cavities in the quartz, associated frequently with gold and galena, and sometimes with copper and manganese. It is also found in brecciated masses of quartz and slate, cemented by brown iron ore. A very extensive plant of machinery has been erected in this district by Melbourne capitalists, to extract the silver; but as yet, their success has been indifferent, much of the silver being lost in the treatment, whilst the expense of working it is considerable. In St. Arnaud's, we have the exceptional occurrence of frequent cross lodes, a circumstance which may possibly have something to do with the variety of mineral ores in which the reefs of this district abound. The report of Mr. George Ulrich, government geologist, who made a special survey of this field, is well worth a perusal.

Antimony has been found in large quantities at Anderson's Creek, and also at M'Ivor's. In both these places, it is found in lodes of great thickness, which sometimes yield over sixty per cent. of pure antimony.

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Iron is plentifully distributed, both in the form of brown ore, and in pyrites. Throughout all the gold fields, it is found traversing beds of sandstone, filling up the broken joints in irregular quartz reefs, and cementing, as already explained, beds of alluvial drift.

Galena and Arsenical pyrites are also very generally distributed. The former is usually found at a considerable depth from the surface, and is considered by the miners one of the best indications of the vicinity of gold, and is often found associated with it. Both iron and arsenical pyrites are often highly impregnated with gold; and the separation of the precious metal from these, is now a subject of much consideration amongst the quartz miners of Victoria.

Although every gold field has its quartz reefs, and quartz crushing machinery, the most interesting and important in this branch of mining, are Bendigo, Castlemaine, Tarrengower, and Wood's Point. The latter is the most recently discovered. It is very rich in its yield of quartz gold, and is distinguished by characteristics so entirely different from those hitherto known, as to be well worthy of special consideration.

Mr. D'O. H. Aplin, government geological surveyor, has made a special report on this field; and states, that here the quartz exists in veins which traverse in a more or less horizontal direction, and at different levels, a rock of granitoid or syenitic character occurring as a broad dyke with well defined walls, and differing essentially from granite in its ordinary position as a rock mass.

I shall now endeavour to describe some of the characteristics of those reefs of which I have had some practical experience.

Along the ridges of all the prominent schistoze hills of the Victorian gold fields, quartz reefs are to be found protruding in irregular masses, and these are generally called the "main reefs." There are, however, many reefs which give little or no outward indication of their existence. In some instances a few angular boulders lying imbedded in the loose fractures of the slates, afford the only evidence of their whereabouts, and it is not until these have been traced in irregular fragmentary veins for probably forty or fifty feet that the true reef begins to develop itself; in others, the surface rocks present a firm, compact stratification, without any signs whatever to guide the eye. The uppermost part of the reef, whether protruding from the surface or otherwise, is termed by

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Australian miners the "cap" of the reef, and where this presents itself at or near the surface, both the quartz and the surrounding schist have an irregular and broken-up appearance, which is called a "blow" or "bluff," and it is not until a considerable depth has been attained that the reef assumes a well-defined compact character; and when we consider the enormous deposits of detritus which have gone to form the drifts of the surrounding valleys, we are led to infer that this disturbed and irregular condition of the reefs and their surrounding strata must have originally extended for a very considerable height above the present level of these hills, and that when this deposit was in course of formation, these rocks were probably in a condition which rendered them much more liable to the influences of external action, atmospheric or other, than they are at present. Whether this circumstance has had any connection with the infiltration of gold into the matrix or its distribution amongst the alluvial drifts, is a question not unworthy of consideration. This disturbed appearance is found on the caps of all reefs, and even at a depth of three or four hundred feet—an irregular bluff-like aspect which is not found in their lower limbs. As already stated, the strike of the quartz is coincident with that of the surrounding rocks, and bears within a few degrees of north and south. The angle of dip of the reefs slightly varies from that of the slates, and in their descent pass through different beds both of slate and sandstone, at an angle more or less varying from that of the dip of the rocks with which they are interstratified, and according to the difference of the angles and the thickness of the beds, so will their passage from one bed to another be more or less gradual —the alternation of beds probably affecting the character of the reef itself as well as varying the metals with which it is impregnated; for if the process of infiltration has had anything to do with the formation of metals, or the lodes in which they exist, the infiltration of different leads would produce different results, and it is possible that the existence or non-existence, decrease or increase of gold, may be influenced by the nature of the rocks which at its various angles form the walls of the reef. Some reefs have a "pitch," that is, a dip in the direction of the strike, say from south to north, so that whilst the cap of the reef may be seen protruding from the surface at one point, it will be found to increase its distance from the surface in the direction of the strike in proportion as the angle at which it pitches is greater or less.

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Many reefs have a serrated edge, extending for some distance horizontally, they then suddenly break off and appear at a considerable depth, so that two mines may be in the course of sinking within a few feet of each other, the one striking the reef at the surface, while the other has to be sunk a considerable depth to reach it.

Some have a forked form, the bifurcation taking place close to the cap, from which descend, east and west, distinct limbs, each having its own peculiarities. These are called "saddle" reefs, and the limbs are generally distinguished as lying east and west. These "saddle" reefs sometimes underlie each other at distances varying from 150 to 300 feet, each reef distinct from the other, but all maintaining in their general character considerable resemblance to each other. Most hills contain more than one reef. I have known as many as six parallel reefs within a breadth of 150 yards, each entirely unconnected with the other, all gold-bearing, and each having peculiar characteristics. Sometimes a reef which presents a full body near the surface, or at the cap, becomes attenuated and apparently lost. Perseverance in sinking, however, will generally recover it, and sometimes the only guide by which to follow the reef is the bedding or cleavage of the slate in which it disappeared, and at others a small vein of a dark pasty-looking substance, having a greasy feeling, thoroughly free from grit, is sometimes a sure guide to certain reefs.

Numerous small quartz veins converge into all quartz reefs, generally from the overlying rock; the underlying wall in well-defined reefs generally appearing to cut off all connection with the other underlying beds.

As I have already explained, the nature of the beds through which a quartz reef descends, is regulated in a great measure, by the relative angles of the dips; and the walls of a quartz reef may be either slate or sandstone, but in the majority of well-defined permanent lodes, I have generally found that slate walls prevail, the upper or hanging wall consisting first, of a thin layer of soft slaty casing, a few inches in thickness, easily broken up, and containing numerous small veins of quartz; outside of this layer, a compact slate, of about a foot or nine inches in thickness; and beyond that, a bluish grey sandstone, very tough and difficult to work, the underlying, or foot wall, consisting of a dark blue slate, presenting a smooth, glossy, even face, and easily split into

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thin laminæ. It is very fine in the grain, and frequently contains iron and arsenical pyrites in great abundance.

The forms in which gold is found in quartz, are of endless variety; and the diversity of its habits so great, as to perplex both the theorist and the practical miner. Sometimes running in apparently well-defined veins, it pursues a downward course for a while, and then becomes attenuated, and disappears. Sometimes a thin thread beginning at the surface, leads downward to a rich vein. Some reefs are patchy, having intervals of unproductive quartz every now and then, broken by rich masses of gold. Some have it distributed through the lode in fine, almost imperceptible particles; in others, the gold appears in ferruginous cavities, in a form resembling fine moss; sometimes in milk white quartz, in the form of crystals; and specimens have been found in the very heart of a pure bright quartz crystal; sometimes, as already stated, associated with pyrites. As a general rule, however, if it be possible to apply a rule to a metal which is so erratic in its habits, gold appears, when carefully traced, to run more or less in veins, generally dipping north, and gradually thinning away, but so tortuous in their course, as frequently to render it difficult to follow them. These veins, beginning at no particular elevation, are, I believe, to be found at all levels, and of varying richness, generally, but ultimately attenuating. Sometimes these veins run along one face of the reef, for a short distance, then traversing the quartz, will be found running through crevices and cracks, then disappearing, will suddenly run into the facing slates, and back again into the quartz, and so on. Sometimes where there is a series of parallel lodes, the gold will be found to alternate from the one to the other, breaking into the one reef opposite the point where it appeared to leave the other. It is questionable whether the gold ever runs out, some believing that it is only lost through the ignorance or carelessness of the miner; and there is no doubt that in mining for gold, the most careful observation on the part of the miner, is absolutely necessary at almost every stroke of the pick. Each reef has its own peculiar characteristics, and these must be carefully studied and known to the men who are working in the mine. From want of attention to this rule, much unnecessary labour, and large sums of money, have been expended in a search, which a better knowledge of these details would have shown to be fruitless. Many claims are

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taken up, simply because they are on a good line of reef, and operations begun, without any reference to the run of the gold, dip or pitch of the reef, etc.; and hence, if the shaft be sunk, so to speak, behind a vein of gold, for example, to the south of a vein which dips to the north, the labour, as far as that particular vein is concerned, is utterly futile; and any success which may be met with, is due to the fact of some other distinct vein being struck. It is not, however, always practicable to obtain such information as will guide the miner in his operations; for, in prospecting a new lode of quartz, he must sink his shaft entirely on chance, endeavouring, of course, if possible, to get gold from the surface, and to follow it carefully. Most miners, and many intelligent men, have favourite theories about what they call good-looking quartz, an appearance which is entirely indescribable, and which, I believe, is, in many instances, mere fancy; for gold has been found in abundance in all sorts of quartz. It is true, however, that each district has reefs of a certain character, which are generally more auriferous than those of a different character in the same locality.

It frequently occurs that the spurs or leaders contain more gold than the reef itself, and the junction of a spur or leader with the main body of quartz, is often very rich. Sometimes a reef will be quite unproductive, until joined by one of these leaders, after which, it will become gold-bearing, not only at the line of junction, but for a considerable way down. The leaders traverse the adjoining Silurian beds; and the fact of their being so frequently rich themselves, and, as it were, introducing the gold into the main reef, may possibly tend to support the theory of infiltration.

The fact of these veins of gold usually attenuating as they descend, has led to what I think is an erroneous conclusion, that the yield of gold decreases, or ceases entirely, as the reefs descend; whereas, in my opinion, most reefs contain many distinct veins, interspersed in all directions, and at all levels, the depth of the level exercising no influence on the richness or poverty of the vein. Gold in great abundance has been obtained from quartz reefs in Victoria, at depths varying from a few inches to 450 feet.

In prospecting for gold in quartz, the labour is much more arduous, and the result much more uncertain than in alluvial drifts. The digger generally either contents himself with picking

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up a few loose stones where the reef crops out, or making narrow shallow traverses at intervals across the ridge of the hills.

Much discussion has arisen, chiefly in consequence of Sir Roderick Murchison's papers on the subject, in reference to the existence or non-existence of gold in payable quantities at great depths. Professor M'Coy of Melbourne, amongst others, took up the subject, and, I believe, supported the views of Sir Roderick; and whether these views be correct or otherwise, coming from such authorities, they have had a discouraging effect upon this branch of mining. Many have in consequence been deterred from giving assistance to legitimate enterprise. It was suggested, some years ago, by practical men, that the local Government should (seeing how dependent the colony is on its mining resources) expend a sum in partially testing the question, by sinking a deep shaft of say 1000 feet on some well known line of reef, but this was never carried out; and I am inclined to think that the repeated expressions of opinion on this subject by men of such eminent attainments exercised some influence in preventing this suggestion from obtaining a more favourable reception. Be that as it may, there cannot be a doubt of the great importance of this question; and it is well that it should be thoroughly ventilated, as a proper understanding of it will either serve to check rash speculation or encourage legitimate enterprise. And taking into consideration the fact that the limits of alluvial gold being defined, the supply must, sooner or later, become exhausted, the question, how far it may be profitably sought for in the matrix, and to what limits its existence in this form is confined, is not only of great interest, in a scientific point of view, but is of practical importance to those countries whose prosperity depends upon their gold mines.

Sir Roderick Murchison in his "Siluria," pp. 453-54, remarking on his ideal section, draws the following conclusions:—That gold only exists in payable quantities at or near the surface; that the lodes become impoverished as they increase in depth; and that it can only be profitably extracted from the detritus of denuded hills where these auriferous rocks once cropped out upon the surface. The sketch referred to represents a section of the supposed condition of these hills prior to the denudations which have taken place since their formation, and a dark line considerably below the level of the original surface represents the probable extent of such denudations, and indicates the present line of surface. Whether

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Sir Roderick Murchison, if he had had before him the recent discoveries in Bendigo and elsewhere, would have modified his views, I cannot say; but the question is still open to admit of discussion. Sir Roderick points out the experiences of ancient gold mining in Wales and in Spain, as well as the modern experiences of mining in South America and Mexico, gives the results of his survey of the Ural Mountains, points to the numerous failures in searching for gold in quartz, and judges, from the almost universal want of success, that gold attenuates in its downward course, and that the reefs become less productive the further they descend. He argues from the fact of the large amount of alluvial gold obtained in the depressions and cavities of the hills as compared with the quantity obtained *in situ*, that the original surface of these hills was far more highly suffused with gold than any other part of them. Sir Roderick has evidently given this subject his most careful attention, and supports his views with a formidable array of facts collected from all parts of the world. It cannot be denied that a large number of quartz mining adventures have been failures; that very many reefs which proved very rich at the surface have become poorer in the course of their descent (that is so far as they have been tested), and that the finds of alluvial gold are far in excess of those obtained from quartz. Applying this rule to Victoria, and admitting the facts, I would venture to say a word or two in favour of deep sinking.

There are in Victoria 16,000 quartz miners as against 68,000 alluvial miners—rather less than a fourth. The material that the alluvial miner has to operate upon is so much more easily worked that the progress of his explorations is much greater than that of the quartz miner, so that he lays open a very much larger extent of ground in the same time, and consequently his chances of finding whatever does exist in his territory, so to speak, are much greater than those of the quartz miner. Suppose, for example, a given area of alluvial drift to contain a mass of gold, and suppose the same area of quartz, even near the surface, to contain a similar mass, the probabilities of the alluvial miner finding his mass within a given time are greatly out of proportion to those of the quartz miner meeting with similar success.

The finding, then, of large nuggets in alluvial deposits, upon which so much stress is laid by those in favour of the surface theory, is, perhaps, after all, not such a weighty argument. Large

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alluvial nuggets are very scarce, even on the richest fields; and if we consider the disproportion of labour, and the difference of the material in which the search has to be prosecuted, it is only a natural consequence that the finding of these masses of gold in quartz should be an event of still rarer occurrence. For the same reasons, the fact that more gold is found in alluvial workings than in quartz mining loses much, if not all its value. And whilst it is true that, in some localities, the alluvial drifts have been richer in gold than the reefs from which they were derived (or at least those portions of them which have been wrought), it must be borne in mind that the present extent of these drifts, probably, does not represent one tithe of the denudations from which they were supplied. Whole hills, indeed, mountains containing auriferous rocks, have been eroded and swept away; and it may readily be conceived that a hill containing a comparatively small proportionate distribution of gold, would, in the aggregate, contain a very large amount of the precious metal. During the process of erosion and denudation which reduced these hills to their present level, the gold which they contained found its way into the nearest cavities and depressions, and from its superior gravity, probably, the greater part of it remained there whilst the greater mass of the detritus which accompanied it has, by successive floods, been carried entirely away. It may not be, then, that we are justified in concluding that the relative proportion of gold and drift, as we now see them, afford a correct index to the proportion which the precious metal bore to the rocks in which it was originally contained. Nor because these depressions and cavities contain rich deposits of gold does it absolutely follow that the original surface of the adjacent hills was any richer than it is at the present day, or that were the same process again to take place, beginning at the present level, the resulting detritus would not contain equally valuable deposits of gold. Take, for example, a hill of auriferous rocks, which contained originally, say, half an ounce of gold to the ton; suppose this hill to be worn away by the action of the elements, the probable result would be, that the drifts formed in the cavities and depressions surrounding this hill would yield, say, five ounces to the ton, the baser material having diminished, whilst the gold, from its specific gravity, remained nearly in its original quantity.

Nature, with her vast machinery, having thus both mined and disintegrated the material, it only remains for the miner to wash;

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and could we deal in this wholesale manner with any of the auriferous quartz reefs of Victoria, there would be very few but would be found to contain, in the aggregate, down to their very lowest explored depths, a vast amount of gold; and I do not think that we can, with any degree of safety, derive from the known value of the alluvial deposits of Victoria, any reliable conclusion as to what extent of gold yet remains concealed in its auriferous rocks.

But many reefs which have been rich upon the surface, have become poor in the course of their descent. Well, then, there are, as I have said, 16,000 quartz miners in Victoria. The shafts sunk may be reckoned by tens of thousands; of these, a large proportion are not above 50 feet, a still larger proportion not over 100 feet, and of those sunk to the 400 feet level, there are probably not a score. From this it is evident that, whilst the surface reefs of Victoria have been well explored, little has been done to develop her deep lodes.

The following yields have, within the last six months, been obtained at one crushing from quartz raised from a depth exceeding 400, and in some cases 500 feet, in the district of Bendigo:—Hustler's reef, 500 tons, yielded 996 oz. of gold; New China reef, 400 tons, gave 805 oz.; Cinderella reef, 487 oz.; Prince Alfred reef, 1197 oz., or nearly 100 lbs.; Latham & Watson's, 1000 oz.; and many other large yields are reported from deep shafts.

We see, then, that at least some of these deep shafts have been very successful; and the number of them which have been so, bears a much larger proportion to the extent of operations, than do the successes of shallower sinking bear to the proportion of surface explorations.

May it not then be that there are in all reefs rich and poor levels alternating, and that where the surface yield has become exhausted, it will be found in all cases that by passing through the unproductive region, there will be found at greater depths a constant recurring series of rich veins.

The results of surface explorations cannot, I think, in the face of the facts stated, be accepted as absolutely indicative of what exists underground; and when we consider the very few trials of deep sinking that have actually been made, we cannot wonder that the array of facts from this source is somewhat limited, nor can we for the same reason admit these facts to be exceptions to a general rule. On the contrary, are we not justified in assuming that if others go

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and do likewise, they, too, will meet with success, and that, in the majority of cases, those who have not been successful have hitherto only failed to find because they have failed to search. But whatever may be the true theory as to the existence of gold in its free form, it is at least interesting to know that as the depth increases it is found more abundantly associated with other minerals. But whether this is merely an additional contribution of the precious metal or a change of its form and habits, there are not yet sufficient data on which to found a reliable opinion. We can only say that up to the present time it has been found in both forms in large quantities at depths exceeding 400 feet. The impregnation of gold amongst iron and arsenical pyrites, increasing at great depths, is a fact of great interest, and is attracting the attention of those who believe in the theory of the infiltration of gold; and amongst practical miners the question how to deal with their auriferous pyrites is becoming daily a matter of more and more importance.

That many quartz mining adventures have been attended with failure cannot be denied, but to attach to these failures their due weight, a knowledge of all the circumstances ought to be in the possession of those who wish to use them as data. The causes which have in all parts of the world, as well as in Victoria, contributed to the failure of quartz mining speculations are numerous and varied, and would afford topics for a bulky pamphlet, but I believe that in many cases where a known auriferous reef has been worked, the failures may be attributed to other causes than the mere poverty of the lode.

That quartz mining can be profitably carried on has been sufficiently demonstrated by the Californian and Victorian miners. It is the search for a payable mine that is the serious matter, not the working of it; and when we consider how many years some of our best Cornish copper mines have taken to prospect, and how few gold mines have received one tithe of the trial, we may be inclined to think that gold mining is not, after all, a much more precarious occupation. It is satisfactory to know that the energy and perseverance of the Victorian quartz miner is daily helping us to a solution of all these difficulties; for while he has before his eyes the fact that heavy gold has been obtained in deep ground, he will continue to sink and explore in spite of all theories to the contrary.

In conclusion, I would refer very briefly to the probability of there being still workable gold mines in this country.

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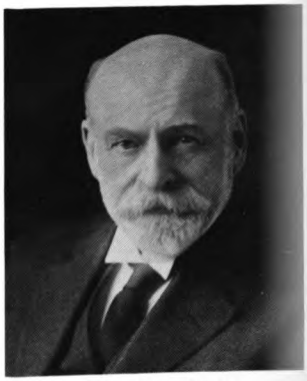

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Sir Roderick Murchison mentions in his "Siluria," page 433, that the Romans found in a place called Gogofau, near Llandovery, a vein of quartz containing iron pyrites highly impregnated with gold, and that in Cornwall pepitas, or nuggets, the size of pigeons' eggs, were found. Professor Ansted states that in a place in Wales, called Dol-y-frwynog, veins containing sixty oz. to the ton were obtained. The Northern Scottish Highlands are also said to contain auriferous reefs, and in the Wicklow Mountains pieces of gold two inches in length have been found. In giving these instances, it is almost invariably added that nothing was found to justify a further search. I can only say that nuggets the size of pigeons' eggs, and pieces of gold two inches long are by no means very plentiful in Victoria, and that the sight of one such would be quite sufficient to induce the Australian digger to prosecute a vigorous search for more.

I am informed that at the present time, in the neighbourhood of the Lead Hills in Scotland, as much as ten shillings worth of gold has been found in a day, and that with very imperfect means. If such be the case, a systematic and vigorous search might be attended with considerable profit. Many of the Welsh quartz mines are still being worked with varying success, very rich quartz being sometimes obtained, but I understand that not much has been done to test these lodes at any great depth.

In any case, the low rate of labour and the facilities for obtaining and working machinery, must give this country a great advantage over Victoria in working and developing its gold mines, and by adopting the improved appliances of the younger country, it is possible that payable gold mines, both in rocks and alluvial deposits, may yet be found in various parts of the United Kingdom.

XLIX. *On the* Relation *between the* Glacial Deposits *of* Scotland *and those of* Canada. By the Rev. Henry W. Crosskey.

(Read February 1st, 1866.)

Principal Dawson, of Montreal, among his other great services to Geology, has very carefully investigated the Canadian glacial beds, and the following notes are suggested by a study of his writings:—

I. The difference between the glacial fossil fauna of Canada and that now existing in the Gulf of St. Lawrence is far less marked

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than the difference between the glacial fauna of the Clyde beds and that now existing in the Firth. The fossil fauna of Canada, in its general aspect, and in the proportions and characteristic varieties of its species, is slightly more arctic than that of the Gulf, but does not present that broad contrast with which we are familiar between the fossil contents of our local clays and the living inhabitants of our waters. There are only two species in Canada which can be regarded as locally extinct, viz., *Leda Portlandica* (Gould), and *Astarte Laurentiana* (Lyell); while in Scotland there is a very remarkable list of species fossil in the clay, but extinct through the whole range of the neighbouring seas. Upon the west, we find:

Tellina calcarea *(proxima)*.	Mangelia pyramidalis.
Saxicava *(Panopæa)* Norvegica.	Natica affinis *(clausa)*
Astarte borealis	Trophon clathratus *(scalariformis)*
Leda pernula.	Velutina undata
Pecten islandicus.	Cyclostrema costulatum
Modiolaria discors.	Balanus cariosus *(Darwin)*
Littorina limata *(Loven)*	

The eastern clays comprise extinct species even more arctic in character, viz.:—

Leda arctica *(Portlandica, Gould)*.	Thracia myopsis.
,, lucida	Cardium Grælandicum.
,, thraciæformis.	Scalaria Grænlandica.
Pecten Greenlandicus	

It is evident, therefore, from this very marked contrast that the change of climate in Scotland has been more complete than in Canada. From this fact important physical consequences ensue: the glacial epoch cannot have been caused by any of those cataclysmal agencies to which it has been attributed. Any heaping up of the land at the North Pole; or passage of the earth through colder regions of space; or shiftings of the earth's axis; or alteration in the heat-conducting power of the atmosphere, would leave, I apprehend, a more uniform distribution of climatic results, and obliterate those delicate proportions of species, varying in different beds of the same epoch, in exact analogy to those variations produced by the causes now at work. To account for the fact we are examining, there must have been a deflection of the Gulf Stream from our coasts. The effect of the Gulf Stream is shown by the lingering of a species like *Saxicava* (Panopæa) *Norvegica* upon the Dogger bank, which is protected

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from its influence, and subject to an arctic current, while it is extinct on the west of Scotland. Moreover, the existence of *Pecten islandicus* in its natural position over large beds in the glacial clay, combined with the fact of its total absence, not only from our present sea, but from any intermediate bed, renders its comparatively sudden extinction by warmer currents taking the place of the more arctic, the most probable hypothesis. The cause of extinction must have been quiet, or its position would not have been so natural, and at the same time sufficiently marked to permit little lingering. The deflexion of the Gulf Stream must be considered in connection with those movements of the land which we know to have been going on in Scotland during the whole epoch. The subsidence indicated by the shell beds at Airdrie and elsewhere was followed by an elevating movement, which, judging from the peculiarly undisturbed arrangement of different clays in various uplifted beds, must have been very gradual. This elevating movement itself also, is proved by the sections given by Mr Jamieson* to have been broken by a second, although slighter subsidence. The shifting arrangements of the boundaries of land and water, occasioned by these undulations of the earth's crust, would materially affect climate, distributing variously the points of insular and more continental temperatures, and in connection with the deflection of the Gulf Stream, would (I am at present disposed to think) sufficiently account for the cold of the glacial epoch. Upon this point, however, Mr Croll's most able and remarkable papers give him a right to be heard, and I would venture to suggest to him the consideration of the variable eccentricity of the earth's orbit (as claimed by his theory) upon the climate of Canada, so as to account for the fact that its temperature was, during the glacial epoch, so little different from that now prevailing, while in Scotland the contrast has been so extreme.

II. Another most important point connected with the Canadian glacial beds, as compared with those of Scotland, is that they occur in a distinct order, whereas in the Clyde district, their order is only a matter of inference.

Dr. Dawson gives some instructive sections. In the lower beds are the deep water fossils, while littoral species occur in ascending order, manifesting the gradual alteration of the old sea bottom.

In collections of Clyde fossil shells we have a mixture of deep coralline, laminarian, and littoral species; but while we have super-

* Journal of Geological Society, Vol. xxi.

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imposed beaches, we have no orderly succession in any exposed section, equivalent *e.g.* to that of Logan's farm, Montreal. This section may prove so useful to our local students that it may be well to quote it as a guide to research:—

	Ft.	In.
1. Soil and sand, ...	1	9
2. Tough reddish clay, ...	0	0½
3. Gray sand; a few specimens of *Saxicava rugosa*, *Mytilus edulis*, *Tellina Grœnlandica*, and *Mya arenaria*—the valves generally united, ...	0	8
4. Tough reddish clay; a few shells of *Astarte Laurentiana* and *Leda Portlandica*, ...	1	1
5. Gray sand, containing detached valves of *Saxicava rugosa*, *Mya truncata*, and *Telllina Grœnlandica;* also *Trichotropis borealis*, *Balanus crenatus*—the shells in three thin layers, ...	0	8
6. Sand and clay, with a few shells, principally *Saxicava*, in detached valves, ...	1	3
7. Band of sandy clay, full of *Natica clausa*, *Trichotropis borealis*, *Fusus tornatus*, *Buccinum undatum*, *Astarte Laurentiana*, *Balanus crenatus*, *&c.*—nearly all the rare and deep sea shells occur in this band, ...	3	0
8. Sand and clay; a few shells of *Astarte* and *Saxicava*, and remains of sea weeds with *Lepralia* attached; also *Foraminifera*, ...	2	0
9. Stony clay, boulder clay, ...		

(*Canadian Naturalist*, Feb., 1859.)

By carefully collecting the fossils from each separate pit in Scotland, and comparing them together, it may be proved, I think, that we have equivalent beds, although our local sections are physically more obscure. Taking our glacial beds as a whole, it cannot be said that they co-existed at one depth, or were even synchronous. The Canadian beds justify the conviction I have long entertained and endeavoured to work out in the field, that our clay beds can be classified, and that there exists a definite order to reward patient research. They also support the proofs we have accumulated in this district of the theory that the rise of land was gradual, and that the passage from the ice epoch to the present was accomplished by forces extending over that vast period of time, necessarily demanded for those very delicate changes, involved in the distribution and redistribution of a specific fauna. It is not simply that a few mollusca disappear from their accustomed haunts

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—a great deal more is involved in a change of climate as it affects a fauna. Zoophytes, Foraminifera, Entomostraca, must gradually alter their proportions and their specific representatives, as well as mollusca, so that between any two marked points of contrast, must stretch vast periods of geologic time.

III. All our Clyde shells occur in beds, resting upon the oldest boulder clay. The absolute absence of fossils, and the superposition of the shell-bearing clays, are facts which prove that the old boulder clays of the west of Scotland are the produce of land ice. The boulder clay appears the base of the section quoted from Logan's farm, just as it is of our Clyde series.

Undoubtedly, however, it is possible to have a boulder clay with marine remains. This may happen in two ways—(1) a glacier may lap over the sea, and melting, deposit the striated stones and mud which it has gathered on its course; or (2) striated boulders may be dropped from floating ice upon the mud beneath, and when the sea-bottom is uplifted, there will be a boulder clay of marine origin.

Patches of boulder-clay containing shells may thus occur along the seaboard, as, for example, at Caithness, and on the east coast of England; but these patches of marine boulder clay will be *newer* than the clay at the base of the Clyde sections. Upon this point I hope soon to submit a detailed argument to the Society. Meanwhile, I remark, as a curious coincidence, that Dr. Dawson pronounces the shells collected from an "indubitable instance of a marine boulder clay" at Riviere du Loup, to be, on the whole, a more modern assemblage than those of the Leda clay of Montreal, which rests UPON the boulder clay.

Dr. Dawson gives one or two localities for fossils in "stony clays of the nature of true till;" but in the greater part of his sections, the fossiliferous beds are superimposed on the boulder clay, exactly as in the Clyde sections.

IV. Very curiously, a bed is noted beneath the boulder clay, for which we have a Scottish equivalent. A peat deposit, with fir roots, is found beneath boulder clay at Cape Breton, while at Chapelhall, Airdrie, we have vegetable remains in the same position—indicating the existence in both countries of land in parts afterwards depressed beneath the sea and again uplifted. The exact climate when this land existed, is believed by Dr. Dawson to have been, at Cape Breton, that of Labrador—in this country I believe it to have been such as to support the *Elephas primigenius*, whose

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remains have been found beneath boulder clay (certainly) at Kilmaurs, and (probably) at Airdrie.

V. The researches of the last few years have brought the Clyde list of fossils into nearer relation to the Canadian list than has hitherto been supposed. The *Leda arctica* from Errol is undoubtedly the *L. Portlandica* of the Canadian beds. This species occurs in such large quantities at Errol as to be characteristic of that clay. The *Astarte compressa* of the Clyde beds is not identical with *A. Laurentiana*, but often approaches exceedingly near to it. *Menestho albula* has been found at Paisley. It is doubtful whether the *Menestho albula* of the Canadian beds is Möller's species. Mr. J. Gwyn Jeffreys considers a specimen from Quebec to which that name has been affixed to be *Scalaria borealis*. Taking the contents of one section, as collected by Dr. Dawson (*Canadian Naturalist*, April, 1865), out of twenty species of *Lamelli branchiata*, fifteen occur fossil in Scotland, and seventeen out of twenty-seven species of *Gasteropoda*.

Speaking generally, about two-thirds of the Scottish fossils at present collected are also fossil in Canada, while the differences are no greater than those which geographical position might easily cause. At the period, therefore, when our glacial fossils lived in the Scottish seas, the climate was nearly the same as that prevailing in Canada during the same epoch—that is, slightly colder than in the present Gulf of St. Lawrence. The fossils, however, can not be considered as marking the extreme point of cold reached during the epoch, but rather as indicating the commencement of slightly milder climatic conditions than had hitherto prevailed. When the deposition of the oldest boulder clay commenced (which it must always be remembered is beneath the shell beds in the Clyde sections), the land must have stood higher than at present, and the temperature would be more intense than during its subsidence.

The question of climate as indicated by the fauna, thus resolves itself into this—what conditions would produce in the Clyde a temperature slightly colder than that of the Gulf of St. Lawrence?

The existence of an arctic current, the wide expanse of land in the American Arctic regions, exercising its chilling influence, and other circumstances connected with the directions of the mountain ranges and heights of the watershed, well known to the physical geographer, sufficiently account for the climate of Canada. A corresponding series of circumstances, therefore, would adequately

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explain the existence of a more arctic climate in Scotland. There is no necessity to introduce causes for the production of cold which do not now exist. Those alterations of level, for which there is ample evidence, would involve re-arrangements of the relative proportions of land and water, and vital changes in the directions of the arctic currents. For the solution of the problems involved in the great history indicated by the fossil fauna of Canada and Scotland, we must first consult those great principles of physical geography, which may now be studied in hourly action over the surface of the globe.

L. *On the Reason why the* CHANGE *of* CLIMATE *in* CANADA *since the* GLACIAL EPOCH *has been less complete than in* SCOTLAND.

By Mr. JAMES CROLL.

(Read March 22nd, 1866.)

AT a former meeting, an interesting paper was read by the Rev. Mr. Crosskey, on the "Relationship between the Fossils of the Glacial beds of Canada and those of the Clyde." In that paper he has shown that the difference between the glacial shells of Canada and those now existing in the Gulf of St. Lawrence is much less marked than the difference between the glacial shells of the Clyde beds and those now existing in the Firth. And from this he justly infers that the change of climate in Canada since the glacial epoch has been far less complete than in Scotland. I agree with Mr. Crosskey in his remark that the true cause must have been a deflection of the Gulf Stream from our coasts during the glacial epoch. If it can be shown that during that epoch the stream was greatly diminished, or perhaps totally stopped, everything appears to me to be accounted for.

The stoppage, or at least great reduction, of the Gulf Stream during the glacial epoch is a consequence which has already been deduced from the Cosmical theory. It, of course, is not supposed that the stoppage of the stream was the cause of the cold of the glacial epoch. On the contrary, it was, we believe, the cold of that epoch which led to the stoppage; but the return of the Gulf Stream to our shores after the glacial epoch, and the consequent great additional rise of temperature due to its return, might

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certainly be the cause why the change of temperature has been much greater in this country than in America. The cold of that period would no doubt be as severe in Canada as in Scotland, but the rise of temperature which succeeded would not be so great in the former country as in the latter. This is obvious, because the temperature of the former has never been raised by the influence of the Gulf Stream; but, on the contrary, has been positively prevented from rising to its normal condition by the cold polar stream from Davis Straits.

If the glacial epoch was due to the cause assigned on a former occasion, then we are almost certain the Gulf Stream must have been enormously reduced, if not altogether stopped, during that epoch. At present the Equatorial current of the Atlantic on approaching Cape St. Roque, divides itself into two portions, the principal portion flowing into the Gulf of Mexico, and forming what is known as the Gulf Stream; the other portion directing its course along the coast of Brazil into the Southern Ocean. The position of the equatorial current is determined in a great measure by the relative strength of the N.E. and S.E. trade winds. It has been proved that during a glacial period on the northern hemisphere the N.E. trades, owing to the great difference between the temperatures of the two hemispheres in polar regions, would enormously predominate over the S.E. trades, and the consequence would be that the equatorial current, the feeder of the Gulf Stream, would be driven considerably to the south of its present position. And in this case the greater portion, if not the entire current, would be turned into the southern branch along the Brazilian coast. The Gulf Stream would, therefore, be greatly diminished, if not altogether stopped. Any one may convince himself by an examination of a chart of ocean currents that if the equatorial current were to be pushed a few degrees to the south of its present position, not a single drop would probably flow into the Gulf of Mexico.

The return of the Gulf Stream has raised the mean annual temperature of Glasgow no less than 15° above the normal, while Canada, deprived of its influence, and exposed to a cold stream from polar regions, has been kept nearly as much below the normal.

Let us compare the present temperature of the two countries. In making our comparison we must, of course, compare places on the same latitude. It will not do, for example, to compare Glasgow with Montreal or Quebec, places on the latitude of the south of

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France and north of Italy. It will be found that the difference of temperature between the two countries is so enormous as to appear scarcely credible to those who have not examined the matter. The temperatures have all been taken from Professor Dove's work on the "Distribution of Heat over the Surface of the Globe," and his tables published in the Report of the British Association for 1847.

The mean temperature of Glasgow for January is 38° F., while in some parts of Labrador, on the same latitude, and all along the central parts of North America lying to the north of Upper Canada, it is actually 10°, and in many places 13° below Zero. The January temperature at the Cumberland House, which is situated on the latitude of the centre of England, is more than 13° below Zero. Here is a difference of no less than 51°. The normal temperature for the month of January in the latitude of Glasgow, according to Professor Dove, is 10°. Consequently, owing to the influence of the Gulf Stream, we are 28° warmer during that month than we would otherwise be, while vast tracts of country in America are 23° colder than they should be.

The July temperature of Glasgow is 61°, while on the same latitude in Labrador and places to the west, it is only 49°. Glasgow during that month is 3° above the normal temperature, while America, owing to the influence of the cold polar stream, is 9° below it. The mean annual temperature of Glasgow is 50°, while in America, on the same latitude, it is only 30°, and in many places as low as 23°. The mean normal temperature for the whole year is 35°. Our mean annual temperature is therefore 15° above the normal, and that of America from 5° to 12° below it. The American winters are excessively cold, owing to the continental character of the climate, and the absence of any benefit from the Gulf Stream, while the summers, which would otherwise be warm, are, in the latitude of Glasgow, cooled down to a great extent by the cold ice from Greenland; and the consequence is, that the mean annual temperature is about 20° or 27° below that of ours. The mean annual temperature of the gulf of St. Lawrence is as low as that of Lapland or Iceland. It is no wonder, then, that the shells which flourished in Canada during the glacial epoch have not left the gulf and the neighbouring seas.

We have good reason to believe that the climate of America during the glacial epoch was even then somewhat more severe than

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that of Western Europe, for the erratics of America extend as far south as latitude 40°, while on the old continent they are not found much beyond lat. 50°. This difference may have resulted from the fact that the western side of a continent is always warmer than the eastern.

In order to determine whether the cold was as great in America during the glacial epoch as in Western Europe, we must not compare the fossils found in the glacial beds about Montreal, for example, with those found in the Clyde beds, for Montreal lies much further to the south than the Clyde. The Clyde beds must be compared with those of Labrador, while the beds of Montreal must be compared with those of the south of France and the north of Italy, if any are to be found there.

On the whole, it may be concluded that had the Gulf Stream not returned to our shores at the close of the glacial epoch, and had its place been supplied by a cold stream from the polar regions, similar to that which washes the shores of North America, it is highly probable that nearly every species found in our glacial beds would have had their representatives flourishing in the British seas at the present day.

It is no doubt true that when we compare the places in which the Canadian shell beds, referred to by Mr. Crosskey, are situated, with places on the same latitude in Europe, the difference of climate is not so great as between Scotland and those places which we have been considering; but still the difference is sufficiently great to account for why the change of climate in Canada has been less complete than in Scotland.

LI. *On the Range and Occurrence of* ANTHRACOSIA *and* OTHER SHELLS *in the Coal Measures eastward of Glasgow.* By Mr. R. WHYTE SKIPSEY.

(Read February 1st, 1866.)

IN bringing these shells under the notice of the Society, the chief object is to direct attention to the conditions under which they are found. The area chosen for description is eastward of Glasgow, and extends from Shettleston eastward to Bargeddie—a distance of about five miles—and from the line of the Monkland Canal, on the

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north, to the River Clyde, on the south—about three miles—its boundaries, as well as its centre, containing an uninterrupted series of coal-workings.

As a rule, the coal strata eastward of Glasgow dip towards its southern border to such an extent that, while the "main" and "hard" coal seams are wrought at about twenty-five and fifty fathoms respectively, at the north and towards the centre of the basin, they are wrought in the southern portion at the depth of from 70 to 80 fathoms, and from 110 to 120 fathoms respectively.

It is in the deepest workings where the shells are found, not only in greater profusion, but more numerous in genera and species, and in a more perfect state of preservation. Their vertical range extends from the "Ell" down to the roof of the "Splint," or "hard" coal, below which they disappear almost entirely, and in most instances altogether.

Anthracosia is represented by the following species:—*A. ovalis*, *A. aquilina*, *A. robusta*, *A. acutum*, and *A. Urii*. The first three are not very abundant, *A. acutum* is extremely rare, while *A. Urii* is not only more widely distributed, but is profusely abundant. It was first noticed by Ure in his "History of Rutherglen and East Kilbride," 1793, and figured pl. XVI., fig. 4. What is termed "musselband" ironstone in this district, is simply a mass of the single valves of this species, cemented together by clay ironstone. It is found ranging from the highest bed in the coal series to the roof of the "Splint," although its usual position is between the "main" and "Splint" coals; but there are several divisions of it in detached masses, and also forming persistent beds; and from its capability of sustaining a fine polish it has acquired the local name of the "Cambuslang marble."

Anthracoptera.—Two species occur, viz., *A carinata* and *A. modiolaris*. With these there is found a form of *Anthracoptera*, approaching the former in appearance: it is more extended posteriorly, while the ridge is considerably more convex and oblique than in the typical *A. carinata*. It is perhaps only a variety. It is tolerably abundant. *A. modiolaris* is found at two of the pits at Bargeddie; but it is, on the whole, a rare species. *Anthracoptera* has been found as high as the "Ell" coal.

Anthracomya.—A single species only. *A. modiolaris* is found generally diffused over the district.

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The whole of these species of coal shells are usually found in most perfect condition in the greyish-coloured shales. In the black bituminous shale they seldom occur, and then in single valves, *Anthracosia Urii* being the predominating species. They are also met with in the ironstone nodules which abound in the shales. Some of the specimens exist in the form of casts merely, but these frequently exhibit the muscular impressions.

In certain other districts of the Lanarkshire coal-fields the coal shells have a wider range than in the area to which these observations are confined. In the Airdrie district, for example, near Holytown, casts of the *Anthracosia robusta* occur very abundantly in the fire-clay immediately overlying the "Kiltongue" coal—a position upwards of twenty fathoms under the "hard" or "Splint" coal—while at Chapelhall it is found in great numbers in the shale which here forms the roof of the upper "Drumgray" coal, a seam about seven fathoms lower than the "Kiltongue." At Quarter, westward from Hamilton, *Anthracosia Urii*, *A. ovalis*, and *Anthracoptera carinata* occur very plentifully in the shale roof of the black-band ironstone, fourteen fathoms under the "splint," but the specimens are much smaller in size than at any of the other localities previously noticed.

This group of shells was for a long time considered by some palæontologists to have been inhabitants of fresh-water, while others regarded brackish or estuarine conditions as their true habitat. Of late this latter view has been adopted both by Mr. E. W. Binney, F.G.S., and Mr. J. W. Salter, F.G.S.; while Principal Dawson, of Montreal, from long-continued observation in the Nova Scotia coal-field, considers that the "balance of probability is in favour of the conclusion that they were brackish-water or fresh-water shells allied to *Mytilidæ* or to Embryonic *Unionidæ*."—(*Quart. Journ. Geol. Soc.*, Vol. XXII., p. 144.)

Although in the district under notice I have never observed them associated with true ocean types of Mollusca, I am informed that Dr. Rankin, of Carluke, has found one or two examples of *Anthracosia robusta* in the marine limestone series of his neighbourhood. At many of the workings near the Clyde, as well as at the Monkland Canal, *Spirorbis carbonarius* is frequently found attached to the shells; while another species, *S. helicteres* (Salter), occurs at Newton, near Cambuslang, in the shale overlying the black-band ironstone. At Provanhall, *Cythere fabulina* and *C. Rankiniana* accompany the

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Anthracosiæ. The *Geological Magazine* for December, 1855, records *Anthracosiæ* (species not given) to have been found in the Staffordshire coal-field, along with marine shells.

In my late discovery of true marine forms at Drumpark in strata overlying all the upper coal seams (*Trans.* p. 52), I had anticipated that the further sinking of the pit would have revealed a deposit of similar fossils, but it has now reached one hundred and three fathoms, where the "main" coal has been found, while the upper or "soft" coal occurs at eighty-three fathoms, and the "Ell" coal at ninety-six, all these seams showing perfect regularity of position, without any slip to indicate an upthrow of the lower carboniferous beds, while the overlying shales enclose *Anthracosiæ* and *Anthracoptera* in perfect agreement with similar forms found in like positions at the workings in the vicinity.

LII. *Notes on the Occurrence and Range of* LINGULA *in the Carboniferous Series of the West of Scotland.* By JOHN YOUNG.

(Read February 1st, 1866.)

UP till the present time, the carboniferous limestone series of the west of Scotland has yielded but four species of Lingula, the position and range of which I will indicate in the following brief notes:—

They have been named as follows:—*Lingula squamiformis*, *L. mytiloides*, *L. Scotica*, and *L. Thomsonii*. Figures and descriptions of the first three species are given by Thomas Davidson, Esq., F.R.S., F.G.S., in his Monograph of British Carboniferous Brachiopoda in the volumes of the Palæontographical Society, and also in his Monograph of the Carboniferous Brachiopoda of Scotland.* The last species, *L. Thomsonii*, is figured by Mr. Davidson, but not described, in this Society's Transactions, vol. II. pl. 2.

Lingula squamiformis is the most abundant species in many localities, and is found ranging from the horizon of our lower marine limestones and shales to the higher beds of our upper limestone series. Impressions of its thin and delicately sculptured valves are

* A Monograph of the Carboniferous Brachiopoda of Scotland. Six Plates, 8vo. London, 1860.

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found in many of the ironstones and shales of the Lanarkshire coal-field, on many distinct geological horizons; but nowhere is it found in so great profusion, or of so large a size, as in the lower black-band ironstone wrought at Possil, to the north of Glasgow. It is there found in thousands; but, owing to the specimens being imbedded in a matrix of the gas-coal and ironstone, the shells have been very badly preserved. It also occurs in great numbers in a shale connected with the black-band ironstone wrought at Govan and elsewhere. The finest *Lingula* of this species which I have yet seen from Scottish carboniferous strata were found at a pit sunk to the Possil upper black-band ironstone, at Robroystone, north-east of Glasgow. They occur in a stratum of soft blue shale, which immediately overlies the thick-bedded sandstones wrought a little farther to the north-east, at Bishopbriggs. The shale lies about five hundred feet from the surface, and the *Lingula* are associated with *Goniatites*, *Nucula*, *Cardiomorpha*, and several other genera of marine shells. One curious fact in the mode of occurrence of the *Lingula* in this bed, and which I have also observed in a somewhat similar shale at Dalry, in Ayrshire, is that most of the shells are found in their natural vertical position, instead of being compressed in the usual horizontal manner. This proves that the silt had accumulated round the *Lingula* during their lifetime, and that their delicate shells had never been tossed about after death by the rude currents of the ocean, so that their fine state of preservation in the strata of this locality may be easily accounted for from this circumstance.

L. mytiloides is not so abundant a species in the Glasgow coal-field as the former, but is found in considerable numbers in the ironstones and shales of other localities, as on the banks of the Avon near Strathaven, and in the shales at Dalry, and at Craigen-glen, Campsie. It is found along with the former in the shale at Robroystone, and it is also found above the limestone which was wrought at the quarries adjoining. Many of the specimens are of a fine bluish colour, and were, according to Mr. Davidson, probably of a bright green colour when alive, like some of the recent species. It seems to have had a greater life-range through the strata than *L. squamiformis*, being found from our lower limestones up to the horizon of the slaty band ironstone of the Lanarkshire coalfield, which is one hundred and sixty fathoms under the "ell" coal. The highest horizon in which *L. squamiformis* has been detected is

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in strata about three hundred and seventeen fathoms below the "ell" coal. In the Permian formation of England, remains of a *Lingula* are found, so closely related to *L. mytiloides* of our carboniferous rocks, that it is doubted very much whether they are specifically distinct, and it is more than probable that it may have lived throughout all the coal period and continued into the Permian, now ascertained to be the case with several other species of carboniferous shells.

One of our recently discovered Scottish species, *L. Scotica*, is not common, so far as yet observed. It has only been found in Lanarkshire, where it occurs in two well defined horizons, viz., at two hundred and thirty-nine fathoms, and three hundred fathoms below the "ell" coal. It has also been found in strata at Boghead near Hamilton, the position of which has not yet been fully determined. *L. Scotica* had been long known to certain collectors in the Lanarkshire coalfield, but, from its peculiar shape, it was not until the last few years that it was identified as a true *Lingula*. Mr. Davidson having had his attention drawn to it by me, found it to be a species new to science. It was therefore figured, and described for the first time in his excellent "Monograph of Scottish Carboniferous Brachiopoda." Although this species has only been found in three or four localities in Lanarkshire up to the present time, further researches may prove its existence in other tracts of our Scottish coalfields. In the Glasgow district, it has been found at Robroystone, at two hundred and thirty-nine fathoms below the "ell" coal; and it also occurs on the same horizon at Gare, near Carluke, where it was first discovered by Dr. Rankin.

The other new species, *L. Thomsonii*, was found by Mr. James Thomson in a band of arenaceous limestone in Tirfergus glen, near Campbeltown. It is a rare species and has not yet been detected in any other locality. It is distinguished from *L. squamiformis*, to which it nearly approximates in form, by possessing, on well preserved specimens, traces of faint, longitudinal striæ, which is its principal specific character.

The following is a list of some of the principal localities and the nature of the strata in the immediate neighbourhood of Glasgow in which carboniferous *Lingula* are found:—

Possil and Keppoch-hill Pits, N.W. of Glasgow; in ironstone mixed with coal.

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Inkerman, Paisley; Dalry, Ayrshire; Govan, Gartnavel, and Kelvinside Pits; in dark slaty shale above the Govan Blackband ironstone.

Orchard Quarry, south of Glasgow; in shale and ironstone nodules overlying limestone.

East-Kilbride and High Blantyre; in shale and ironstone nodules.

Boghead, near Hamilton; in nodules of ironstone.

Strathaven; in clayband ironstone and shale.

Bishopbriggs and Robroystone; in shales and ironstone nodules.

Craigenglen, Millburn, and Main limestone quarries, Campsie; in soft shales, calcareous shales, and clay ironstone nodules.

Corrieburn, east of Campsie; in sandy shale and clay ironstone.

The minute researches which have been made into all the fossiliferous strata of our Lanarkshire field during the last few years, by earnest and careful collectors, have revealed no new forms of *Lingula* which can be considered specifically distinct from any of the four species mentioned in this paper, so that the list of Scottish carboniferous species is not likely to be much farther extended. *Lingula* are found ranging through a series of beds in the Lanarkshire coalfield nearly two thousand feet in thickness; but their remains are seldom found in our purer limestones. They seem to have been a class of shells that loved an argillaceous deposit for their residence, rather than one entirely calcareous, so that they are more abundant in some of the clay ironstones and shales than in any other strata. There is one limestone in the Lanarkshire field known by the name of the "*Lingula*" limestone, but it is more of a calcareous shale than a pure limestone, so that what is here stated will be found to be generally correct, that carboniferous *Lingula* are often to be found in greatest abundance in strata where the principal base is clay. As formerly mentioned, the same species of *Lingula* is found in the Lanarkshire field, occurring in the same district on two or three distinct geological horizons; and it becomes an interesting question to consider what has led to its sudden extinction, and its reappearance in the same locality in a higher series of beds. And in our investigations we often find in certain strata, which must at one time have occupied a considerable area of an old sea-bottom, the remains of a whole colony of *Lingula* and other marine shells which have become suddenly extinct, overlaid by a series of beds in which few traces of shells or any other organisms are to be found. After ascending through a series

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of unfossiliferous beds of greater or less thickness, we again find the same forms of organic life reappearing. Perhaps during the long period in which the intermediate strata were being deposited, some of the species found in the lower beds disappeared from these seas, and other new forms took their place; and these, after flourishing for a period over nearly the same tracts, again became suddenly extinct, left their remains in the strata, and were again overlaid by another series of unfossiliferous beds, and this reappearance and extinction of life over certain areas is found to be frequently repeated in that group of rocks which forms the middle division of our Scottish coalfield. These sudden extinctions of organic life may have arisen from several distinct causes, such as a change in the nature of the deposit, or from some deleterious sediment spread over the sea-bottom, killing suddenly the life of the period over that particular area; or they may have been destroyed by a depression of the earth's crust, causing the sea-bottom to sink to a lower level, and producing a change of temperature and pressure which became fatal to their existence. Of such changes, we have evidence in several of our coal-seams, formed of the remains of a terrestrial vegetation accumulated in swamps at, or near the sea level, and now found to be overlaid by a great thickness of fossiliferous marine strata. But wherever we find a sudden extinction of the organic life in any stratum, we are not to suppose that such extinction was universal. In most cases it must have been only comparatively local, for a total extinction would imply a new creation of the same forms in every succeeding stage of strata in which they are met with. The most probable supposition is, that during all the long geological ages in which our fossiliferous strata were being deposited, or from the first appearance of life on our globe, there never has been, at any one time, a total extinction of the Flora and Fauna, from that remote period till the present time; and when we find in our coal-measures the constant reappearance of certain well-known species, after each local extinction, in higher and higher stages of strata in the same locality, we are naturally led to conclude that, while they became extinct over these tracts, they must have continued flourishing in other parts of our carboniferous sea, and that they spread from these spots into their old localities, whenever the condition of the sea-bottom again became favourable to their growth and development.

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LIII. *Description of* LINGULA THOMSONII, *Trans. Geol. Soc. Glasgow*, Vol. II., pl. ii., figs. 3, 3*a*, 3*b*. By THOMAS DAVIDSON, Esq., F.R.S., F.G.S.

Sp. Char.—Shell, longitudinally oblong; broadish anteriorly; sides, sub-parallel; beak, obtusely angular; valves, convex; surface, longitudinally, and finely striated; length, 4½; width, 3 lines.

Loc.—Carb. limestone, Tirfergus glen, near Campbeltown.

LIV. *On the Occurrence of* COAL BEDS *under the Traps of the* BOWLING HILLS. By Mr. ALEXANDER CURRIE.

(Communicated by Mr. John Young.)

(Read April 12th, 1866.)

WITH the view of corroborating the opinions held by various members of this society, in opposition to those put forth by the officers of the Government Geological Survey, I have to bring under their notice the occurrence of certain coal seams which have come under my observation, and which, being overlaid by the traps of the Bowling Hills, may help to throw some light on the age of these igneous rocks which form the western termination of the Kilpatrick range.

The physical aspect of this beautiful range of hills must be familiar to all who have sailed up and down the Clyde, or who have had the pleasure of rambling among them and examining their structure. From near Old Kilpatrick to Dumbarton they impinge on the shores of the Clyde, forming in some parts of the foreground a series of abrupt conical heights, such as Dunglass, Dumbuck, and Dumbarton rock; while in the background there are the lofty terraced fronts of the Long Craigs and other eminences, the whole presenting a scene only to be witnessed among the trap-hills of Scotland. The age of these igneous outbursts, which form part of the great chain of trappean heights, extending across Scotland, from Ardrossan on the Clyde to near Montrose on the German Ocean, has always been a subject of interest to those engaged in their investigation, and can only be satisfactorily determined by the age of any sedimentary strata,

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which they overlie, erupt, or otherwise disturb. The officers of the Geological Survey, in their new sketch map, have coloured this great chain of trap-hills as of Old Red Sandstone age, holding that they were erupted before our carboniferous strata were deposited. If such were the case, they ought not to be found overlying or altering the beds along their margins, as it has been clearly shown they unquestionably do, in many sections along their course through our western coalfield, and as the section which I now bring under notice not less clearly proves. The section referred to, may be seen in Auchentorlie Glen, an interesting ravine on the hillside, immediately to the west of the village of Bowling. On entering the glen, a little to the north of the Dumbarton Road, the stream is seen to have cut its way through an overlying bed of greenstone containing crystals of glassy felspar, which rock forms the sides of the glen in its lower reaches, and dips southwards towards the Clyde. A little way up on the left side, there is a cave-like recess under the trap, partly filled with water, which has been formed by the scooping out of a bed of coal and shale which crops out near the level of the stream. At this point the trap is seen resting on the coal, which dips to the south-west at an angle of 26°, and is about two and a half feet in thickness. It is considerably burnt in its upper part, but some of it gives off a little flame. Between the coal and the trap there is a thin bed of clay shale, and another shale underlies the coal; but its thickness cannot be ascertained, owing to its position, which is on the level of the stream. The trap, where in contact with the coal, has been changed into a light coloured rock, but a little higher in the bed it resumes its normal tinge of a dark blueish grey. A few yards higher up the glen, there is a small waterfall, where the stream tumbles over a ledge of the trap which overlies the coal. The strata here dips to the south-east at an angle of 24°. The coal-bed stretches right across the stream, and is overlaid by, and rests on, clay shale as in the former section; but without boring, it is impossible to say what thickness of coal strata may exist, nor, in the absence of organic remains, can the relationship of this bed to our other coal strata, be satisfactorily ascertained. That it belongs to the coal measures proper I have little doubt, although occurring nearly two and a half miles within the trappean border; but whether its position is above or below the Hurlet or Campsie series I am unable at present to say. However, the lowest bedded traps of this part of the Kilpatrick

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range, rest directly on carboniferous strata, which they have also burnt on the upper side, and cannot, therefore, be of Old Red Sandstone age, as assumed by the Government surveyors. I have not found this seam of coal higher up the glen than the first waterfall; the middle reaches of the glen are composed of bedded traps, chiefly of a greenstone character, sometimes parted by beds of trappean ash of varying thickness, and of the same character as those found in other parts of the range. These continue to an elevation of 600 feet or so above the level of the Clyde, where there is a second waterfall. Turning off here, on the west side of the glen, from the bed of the stream, and rounding a corner of the hill, a very fine view of the estuary of the Clyde is obtained, and at this point another variety of coal occurs, also overlaid by trap. It is about a foot in thickness, of a brown peaty colour. When dug out it is very soft, and soils the fingers like burnt cork; the woody fibre in this deposit is distinctly visible, but it can hardly be considered a true coal, as it crumbles to powder on the slightest touch, and has apparently been burnt into a state of charcoal, and has never been much mineralised. Between it and the trap which overlies it, there are one or two inches of a slaty shale, and a similiar shale lies underneath it. This curious bed lies right amidst the traps of the hill, the bed of porphyritic greenstone which overlies it being of considerable thickness. It has all the appearance of being contemporaneous with the trap, and may have been part of an old coal marsh, which had been covered over by one of the lava streams which form these hills. It is evidently quite conformable to the trap-beds on the hillside, which all dip to the south-east, as may be seen on the hillside to the westward, where the trap beds terminate in a succession of terraces, and overlie a thick-bedded white sandstone, a member of the Ballagan and Levenside limestone series. This group occurs in several glens to the westward, and is intermediate between the Coal Measures and the Old Red Sandstone in the valley of the Leven. I have no doubt that the Government surveyors will yet see the necessity of reconsidering their views as to the age of our trap hills, when they have an opportunity of investigating more correctly the facts revealed in this part of the range, as well as in many other localities.

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LV. *On the Occurrence of* Bos longifrons *and* Bos Primigenus *in the* Ancient Drift *of the* Clyde. By Mr. James Bennie.

(Read April 12th, 1866.)

The usual tendency of knowledge to beget knowledge, by the increased power of observation which it confers, has been repeatedly experienced during the researches I have been recently making in the surface deposits of our district. The clue to the character and sequence of the various beds which was obtained from the sections exposed in Windmillcroft has enabled me to determine, without that minute study that was formerly absolutely necessary, the sections I have since seen elsewhere—the rate of discovery being of course accelerated by improvement in the means of research. In consequence of this, I have seen more during the few months that have elapsed since I obtained this power of understanding what I see and find, than in whole years previously; but as these are simply confirmatory of the conclusions regarding the surface geology of Glasgow contained in my former paper, it is not necessary to enter into any details concerning them. I will, therefore, pass to two or three things which are new, at least in my acquaintance with these old river drifts.

These are—the occurrence in true river drift at Rutherglen Loan, Gorbals, of a part of the forehead of a small ox, which Dr. Scouler has recognised as that of the *Bos longifrons*, one of the extinct cattle of Clydesdale; and in similar drift in Greendyke Street, of a horn which Dr. Scouler has also recognised as that of the *Bos primigenus*, another of these old Clydesdale cattle.

The excavation in Rutherglen Loan was for a sewer extending from Rose Street to Commercial Boad, a distance of several hundred yards. It was seven or eight feet deep, and except at one part, where a ridge of brick clay projected upwards about a foot into the section, the soil cut through was clearly and unmistakably river sand and gravel, as it was characterised throughout by the same kind of vegetable remains which mark the Clyde drift so emphatically elsewhere. Fragments of trees, well-rounded pebbles, hazel nuts, acorns, pieces of bark much waterworn, and other debris of the same kind, were frequent on the sand. Leaf beds also occurred repeatedly, but they were not thick or persistent. The only peculiarity that I noticed in them was, that they were traversed

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vertically by hollow vegetable tubes, so well preserved that some of them were still green. These I supposed to be roots of water-plants living in the river, and sending down their roots into the leaf-beds that lay beneath them. It was upon a heap of grey sand, well marked by vegetable *debris*, that I found this forehead of a small ox lying—of course, not *in situ*, but having evidently been dug out of the sand bed by the workmen, from a depth of probably seven feet, as the hollows in it were filled with a fine grey sand that occurred at that depth, and, besides, it had every appearance of having lain long in water before it was silted up. I have, therefore, little hesitation in inferring that it belonged to the canoe period of the Clyde. This conclusion seems quite confirmed by the two oval holes that occur in the middle of the forehead, which are evidently not accidental, but the result of intelligence working with tools for a purposed end. The precise end, however, is difficult to determine, as the most obvious one, that they served to put a string or thong through, by which the skull might have been used as a weight, seems inadmissible, as a stone would have answered so much better as a weight or sinker. Be that as it may, it is a gain to know that these old oxen were coeval with the canoemen, living with them, wild or tame, in the same woods, perhaps furnishing them at times with food, and thereby varying their otherwise perpetually lenten fare of fish, with a beefsteak now and then, let us hope.

In the same heap of sand I found a small perforated stone, the precise use of which is uncertain, as its weight, less than half-an-ounce, militates against its having been used as the other perforated stones probably were, as sinkers; but it has been suggested that it might have served as a secondary sinker, to keep in a horizontal position an inner portion of a fishing-line that was anchored by a regular sinker at the end.

The excavation in Greendyke Street, in which the horn of the *Bos primigenus* was found, was also for a sewer, and extended from Lanark Street to the foot of Charlotte Street, and thence up Charlotte Street to the Free Church. The depth was about ten feet, and the soil cut through consisted partly of forced earth, vegetable mould, and river silt—the silt being where the horn was found seven feet deep. This silt differed in some respects from other silts, being very earthy and black, and seemed to be composed wholly in many places of comminuted vegetable soil. So much was this the

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case, that if there had been no leaf beds in it I would have considered it as such altogether, but the leaf beds marked it as river silt beyond doubt. The leaf beds were not thick but they were numerous, and consisted as usual of leaves of trees, sprigs of moss, and the like, all laid flat and spread out as they had sank overloaded by saturation. They were pierced by innumerable roots of water plants, native to the silt and the river that deposited it. It was rather a strange sight to see those roots standing across the lines of stratification and transfixing the dead leaves they had grown through, and it assisted the mind to realise the course of events without much effort. Very little driftwood occurred in this silt, and no nuts. Passing by one day I saw a large horn and a rib lying upon a plank, where they had been placed by the workmen. As I thought them significant enough to be preserved, I asked them and they were at once given to me. Of course, in such circumstances we cannot know the exact depth they occupied in the bed, but that they had been in it was manifested conclusively by their being dyed black by the decaying vegetable matter diffused through the bed. The rib is considered by Dr. Scouler to have probably belonged to a red deer.

In the Charlotte Street part of the excavation, the strata changed interestingly, from river silt and clay to sea silt and brick clay. First, the leaf-bedded silt stopped abruptly, abutting against a bank of brick clay, a light yellow clay (which must be of fresh water origin, for I have seen it in many places capping the whole series of river drifts), extended for a dozen yards or so over the brick clay, but it also cropped out and the brick clay extended throughout the whole section, which was then ten feet deep. I washed several parcels of it for shells, but with no result, notwithstanding, I have no doubt it was of marine origin, and belonged to the later periods of the glacial epoch.

From the almost accidental manner in which these relics were found, it is obvious that others might be obtained, if every similar disturbance of our old river drifts was searched, however cursorily in the same way, and certainly it behoves the members of the Geological Society of Glasgow, more than others, to let no opportunity pass unimproved of adding to their knowledge of the district they profess specially to study.

After all that has been said about the canoe period our knowledge of it is exceedingly imperfect, and of the canoe men, apart

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from their canoes, we know absolutely nothing. Let the search for more canoes and other sinkers be continued and extended, and it cannot be but it will meet with due reward. More are certainly to be had. Within the last few weeks another sinker has been found in Windmillcroft, by Mr. James Manwell, which not only is the best made, but its character of a sinker is placed beyond all possibility of doubt, by the perforation being situated at the one end as in the modern sinker. Another has been found by Mr. Fraser Christie, in the bed of the Clyde, at Westhorn, which had evidently been washed out of some old gravel bed by the present Clyde. It is semiglobose in shape, composed of a soft coarse sandstone, with the perforation in the centre, the edges of which are neatly bevelled.

LVI. Geological Notes and Queries.

Notes on the method adopted in collecting and mounting Entomostraca and Foraminifera, from the Carboniferous strata of the West of Scotland.—Having been requested to give a few general directions regarding the methods adopted by members of this Society, in searching for minute fossils, I gladly comply, by stating the various processes which have been so successfully employed in extracting many species of Foraminifera, Entomostraca, and minute shells, found in our limestones and shales. And while doing this, I may state that we do not claim any originality for our plan, which is that probably followed by Geologists in other localities, although we have never met with any description of their *modus operandi*.

When we first began to pay any attention to the collecting of Entomostraca, etc., we selected specimens only of the limestones, ironstone, and hard shales containing them; and to get them extracted from the stone we broke it up into small fragments, and crushed these into a coarse powdery condition by means of a pair of wire cutters which do not go quite close in the head; by this means the great bulk of the specimens are freed from the matrix, and far fewer of them are broken in the process than would be imagined. The pounded material is then washed in order to free it from the dust, and afterwards dried and sifted through pieces of

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gauze cloth of different degrees of fineness. When the pounded material is thus assorted, it may then be searched for organisms by sprinkling a small quantity of the material upon a writing slate, with close fitting wooden edges, giving the slate a slight shake from time to time, until we have exhausted the organisms in the material, which is then thrown away, and a fresh supply is again sprinkled on the slate. Before pounding any piece of rock containing Entomostraca, it ought to be closely examined by the glass, to see whether the specimens exist as single valves, or have the valves united in their natural condition, because if they exist in single valves, as in many instances, none of them will be freed from the stone, and are better left in the matrix.

Many of the limestone shales of Scotland are very fossiliferous, and often break up under the influence of the weather into masses of a soft, fragmentary clay. It is well known to our collectors that from some of these soft shale banks, at the old limestone quarries, they have obtained some of their most perfect specimens on the breaking up of the shales. But beyond collecting the larger specimens that are exposed by the washing of the rains, very little has been done in collecting the minuter organisms. Indeed it is only within the last two years that we have ascertained that many of these shales are so rich in new and rare forms of microscopic life. As they are only to be obtained by quiet and patient investigation, the best method of collecting them is to take home a bagful of the fully decomposed shale, when in localities favourable to collecting it. The shale, if very stiff or clayey, is easier washed if first dried in an oven and afterwards steeped in water, when it readily breaks up, and the soft particles of clay float away when washed under a gentle stream of water and stirred about by the hand. This must be continued until the water comes off quite clear: then dry the residue in an oven, and sift it into various degrees of fineness, and search upon the slate as formerly directed. We find that sifting the material assists the searching very much, as the smaller specimens do not get covered by the coarser fragments, and are therefore easier seen.

In collecting shale from the banks, take only that which appears to be most fossiliferous, as we find that shales, as a rule, which do not contain the remains of larger fossils are also comparatively barren in the more minute forms. The more weathered the shale the better, as the specimens come out whiter and cleaner. It may

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be collected from the rain ruts of the banks, where the finer material is carried down, and from the pounded material of old footpaths.

The shales which have thus yielded the greatest variety of organisms are those of Craigenglen, Campsie; Brockley, near Lesmahagow; Calderside, High Blantyre; Boghead, near Hamilton; Orchard, near Pollockshaws; and Robroyston, north of Glasgow. There are perhaps many shales in other localities equally rich, which only require to be properly searched for new and rare forms. Besides Entomostraca and Foraminifera, several plates of *Chiton* and *Chitonellus* have been found in the washing, along with minute univalve and bivalve shells, portions of Crinoids, etc. The small organisms are easily picked off the slate by means of a pin or small sharp-pointed piece of wood, moistened at the point by the tongue.

The mounting of these minute fossils for proper investigation and display must be left to the taste and ability of the individual collecting them. A neat and safe plan of mounting which we have adopted is to take shallow glass-capped boxes, of moderate size; cut circular discs of fine card-paper to fit under the glass, the thickness of the card-paper to be regulated by the size of the specimens, and with a punch made for the purpose, cut out an oblong square nearly the width of the disc, and scalloped at the corners. Paste upon the under side of the disc a piece of fine blue or black card paper, upon which the specimens can be mounted with a little gum, in one or more rows. By this means the specimens are kept under the level of the disc, close to the glass, but not touched or crushed by it, so that the most minute and delicate forms are kept in perfect safety, and without any danger of being rubbed off the card in handling. There is also, by this means, room upon the disc for writing the name and locality of the specimens; and in the box a small piece of the rock can be kept if desired, to show the specimens in the matrix. This method of searching for, and mounting the minute Entomostraca and Foraminifera, found in our glacial clays, has also been successfully adopted, with some slight variations, by those of our members who are investigating these beds. But for the strict method of research above described, we must have remained ignorant of many of the minuter forms of life which peopled the waters of the Carboniferous and Glacial periods.—*John Young, Glasgow: October*, 1866.

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Sections of Traps, Rocks, etc., near Greenock.—The student of physical geology will derive much instruction in an afternoon's ramble from Port-Glasgow to Kilmacolm, and from thence to Greenock, along the railway line in course of formation between it and Johnstone.

Keeping the newer and most frequented road, along which the telegraph lines run, fine examples of porphyritic greenstone are exposed weathered completely white to the depth of half an inch. Near Kilmacolm, in the direction of Greenock, the line of railway has been cut through ordinary greenstone holding some zeolites and blue carbonate of copper. At the farm house, near this section, the greenstone changes into volcanic ash, in which lies one spur, not rich in metal, however, of the copper lode which extends from Lochwinnoch. The lode is here intersected by an oblique trap dyke, which throws it down on one side, while another dyke, fifteen feet in breadth, cuts through it vertically. Onwards towards the contractor's offices, the rock varies to compact greenstone and varieties of ash, sometimes fantastically blended and enveloping large circular masses of hard trap (bombs), the ash sometimes vescicular, and the cavities filled with small brown crystals of carbonate of iron. Further on, the hard traps contain good examples of *Thomsonite* and calc spar, and above Port-Glasgow there is a fine exhibition of beautiful amygdaliod, of the same character (zeolitic and calcareous) as that near Johnstone and at the head of the Shaws waterfall at Greenock, but in better preservation.

At the Greenock cemetery, a tunnel has been driven through the Old Red sandstone, which, with its fine varieties, its conglomerates, and blue and red marls, deserve examination. The sandstone corresponds with that at Farland Point, Isle of Cumbrae, being deep red, with white and bluish spots, and marks of various sizes. *R. White Skipsey, Glasgow: October*, 1866.

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PROCEEDINGS FOR THE YEAR 1865-66.

Annual General Meeting, October 5, 1865.

Edward A. Wünsch, Esq., *Vice-President*, in the Chair.

The minutes of the last meeting, held on April 13, 1865, were read and confirmed.

The Treasurer submitted a docqueted statement of the cash account for the year, showing a balance of £2 8s. 5d. in favour of the Society.

The election of officers for the next twelve months was then proceeded with, and scrutineers having been appointed, the result of the ballot was declared to be as follows:—

James Smith, of Jordanhill, F.R.S., F.G.S., *President.*

Edward A. Wünsch,
Rev. Henry W. Crosskey,
John Scouler, M.D., F.L.S. } *Vice-Presidents.*

James Farie, *Secretary.*

James Horne, *Treasurer.*

James Armstrong, *Librarian and Curator.*

Council.

John Young.	John Sutherland.
Thomas Naismith.	James Sinclair.
James Dairon.	J. Wallace Young
John Dougall.	George R. Alexander.
Joseph Kerr	Andrew Armour.
John Dennison, C.E.	James Thomson.

November 9, 1865.

Edward A. Wünsch, Esq., *Vice-President*, in the Chair.

The minutes of the last meeting were read and confirmed.

The Librarian laid on the table several donations to the library, for which thanks were voted.

The following gentlemen were elected resident members of the Society:—John Mossman, sculptor, 83 North Frederick Street; Daniel Munro, portrait painter, 65 Bath Street; William Cameron, 43 West Regent Street; John Marshall, writer, 41 West George Street; David Rowan, engineer, 52 St. Vincent Crescent; Alexander Paterson, 49 St. Vincent Crescent; David Sclanders, 320 Renfrew Street; Alexander Murray, 66 Rose Street, Garnethill; David Lawson, 201 Sauchiehall Street; Dr. S. E. Smith, 94 West Regent Street; Alexander S. Baird, 14 Queen Street; W. F. Murray, 66

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Garngad Hill; J. W. Napier, coalmaster; James Steel, Port-Dundas; John Masson, 37 Garnethill Street; W. J. Wingate, 14 Lynedoch Crescent; James Alexander, jun., 19 South Frederick Street; John Smith, mining engineer, 112 West George Street.

The SECRETARY exhibited and described a new chart of Fossil Crustacea, arranged and drawn by Messrs. J. W. Salter, F.G.S., and Henry Woodward, F.G.S. This chart is most interesting and valuable. It contains upwards of 490 figures beautifully engraved by Mr. J. W. Lowry, and not only shows at a glance, between transverse lines, the various genera of crustacea belonging to each of the geological formations, but also between curved vertical lines, the first appearance, gradual developement, and range in time, of each of the several orders, from the Cambrian period to the present, the upper transverse section containing recent typical forms illustrative of the fossil group figured below.

The SECRETARY also exhibited and briefly described several fossils from the upper coal-measures of Kilmaurs, Ayrshire, which he had selected from a large number collected by the late Mr. Thomas Brown of Stewarton. They occur finely preserved in clay, ironstone nodules, and are identical with many of those found in similar nodules at Coalbrookdale, in the Shropshire coal field. They consist of ferns, *Neuropteris*, *Cyclopteris*, &c., and other plant remains. There were also some specimens of an articulated organism, resembling *Xylobius*, a myriapod found in the Nova Scotia coal field, and several crustacea. Among the latter, were specimens of *Limulus rotundatus*, and a perfect and beautiful example of *Bellinurus bellulus*, which he described and contrasted with a specimen of the recent *Limulus Moluccanus* from the Indian Ocean—the chief difference in their form being, that the series of thin abdominal overlapping plates of the former, are converted in the latter, into a single triangular-shaped abdominal shield, with five pair of swimming feet attached to it, and terminating, like the other, with a styliform tail-spine.

The Rev. HENRY W. CROSSKEY, Vice-President, having taken the chair, Mr. Edward A. Wünsch exhibited numerous specimens, diagrams, and sections, in illustration of his paper on "The discovery of fossil trees imbedded in Trappean ash in Arran" (p. 97). The specimens consisted of transverse sections of *Lepidodendron*, *Sigillaria*, *Knorria*, &c., some of them measuring fifteen to twenty inches in diameter, as well as of numerous smaller stems, branches and leaflets. The stems, especially in the polished specimens, showed the structure in beautiful preservation.

Mr. JOHN YOUNG supplemented Mr. Wünsch's paper with some more detailed remarks on the mineralogical character of the ash-beds containing the plants, and stated it to be his conviction that the stems were the remains of true fossil forests, and undoubtedly found in the position in which they had grown, the ash-beds, and other sedimentary deposits of this part of the coast of Arran having been slowly accumulated over the coal tracts by the ordinary deposition of the various rock materials during the gradual submergence of the area.

Dr. JAMES BRYCE, F.G.S., author of the "Geology of Arran and Clydesdale," expressed his gratification at seeing a new field of geological research

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opened up in the island of Arran, and described as of the highest interest to geologists,—the fact of fossilized stems of carboniferous wood being found enclosed in a matrix, which even an uninitiated observer would undoubtedly pronounce to be a true volcanic rock.

The meeting then adjourned.

December 7, 1865.

The Rev. Henry W. Crosskey, *Vice-President*, in the Chair.

The Minutes of the last meeting were read and passed, and donations announced, for which thanks were voted.

Mrs. Dougan, 2 Windsor Place, was elected a resident member. The following gentlemen were also elected resident members:—Lewis Charles Alexander, 80 Bath Street; William Ambrose, 152 West George Street; H. R. Adam, 80 Union Street; John Carrick, city architect and master of works; Dr. Hugh Colquhoun, Grosvenor Terrace; Robert Dunlop, 51 Holmhead Street; William Euing, 209 Brandon Place; James Kerr, Western Academy, St. George's Road; James Kennedy, 99 Bath Street; Dr. A. T. Machattie, F.C.S., 100 Ingram Street; James M'Clure, 100 Buchanan Street; Robert Paton, 3 M'Alpine Street; George Young, 28 Hope Street.

Mr. Edward A. Wünsch, referring to a motion of his which had been passed last session for the appointment of a committee for taking steps to mark and record the effects of sea action on the shores of the Frith of Clyde, said he trusted some initiatory steps might be taken in this matter in course of the present session.

Mr. John Young made some observations with reference to the suite of carboniferous fossils exhibited at the meeting, and which had been presented to the museum by Mr. James Linn of Whitburn, one of the Society's corresponding members. He said that amongst them were several interesting corals belonging to *Cyathophyllum*, *Cyathopsis*, *Clisiophyllum*, and *Lithostrotion*. Of the latter, there were several specimens of *L. Portlockii* in fine preservation, showing the weathered cups and the base by which they had been attached. These had been derived from the carboniferous limestone shale exposed in the coast section at Arbigland in Kirkcudbrightshire, where they are found in large rounded masses. They are easily obtained, being often found on the beach, detached from the soft shale by the action of the waves. After a general description of the specimens on the table, Mr. Young concluded his remarks by mentioning that *Lithostrotion Portlockii*, one of the Arbigland corals, was rather a rare species in the carboniferous beds of the West of Scotland, he having only seen it at Corrieburn, on the Campsie Hills.

Mr. James Bennie read a paper "On the Surface Geology of Glasgow" (p. 100), illustrated by a numerous series of specimens of marine shells, Entomostraca, Foraminifera, the remains of the fresh water *Unio*, twigs, portions of moss, nuts, circular-bored stones, &c., all obtained from the beds excavated for the new docks at Windmillcroft on the south of the river Clyde, and other excavations for buildings on both sides of the river.

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The CHAIRMAN, after highly complimenting Mr. Bennie upon his paper, as showing very great perseverance and accuracy of research, and embodying most valuable observations, exhibited a diagram of the various borings made by the Clyde Trustees, to which he referred as confirming the conclusions of the paper.—(See note by the Chairman on Mr. Bennie's paper, p. 115.)

Mr. JOHN BURNS read a paper on the "Encroachments of the Sea on the Coasts of Great Britain," in which he gave a concise account of the inroads of the sea along the coast-line extending from Shetland, and the Orkneys to the Sicilly islands. The writer, while quoting numerous instances of alterations in the coast-line for several centuries back, confined himself chiefly to those noted at various localities during the last fifty or sixty years. He also referred to instances within a limited area, where there was the apparent anomaly of a loss of land at one part and a gain at another part of the same coast-line; and, in conclusion, expressed his opinion that the main causes of such changes were due to ocean currents.

The CHAIRMAN expressed his regret that the lateness of the hour prevented a discussion on the interesting paper just read; and on his motion, a vote of thanks was awarded to Mr. Burns, after which the meeting adjourned.

JANUARY 11, 1866.

Dr. JOHN SCOULER, F.L.S., *Vice-President*, in the Chair.

The minutes of the last meeting were read and signed, and donations to the library announced, for which thanks were voted.

The following gentlemen were elected resident members of the Society:—Michael Connal, Virginia Buildings; James M. Gale, C.E., Corporation Water Works; Edmund Hunt, C.E., 87 St. Vincent Street; James Lillie, 45 Queen Street; James Mackintosh, 3 Abbotsford Place; William West Watson, City Chamberlain; Robert Walker, 8 Ingram street; Robert Walker, Union Villa, Helensburgh; James G. Wilson, M.D., 130 Sauchiehall street.

Mr. JOHN SMITH exhibited a large series of specimens of *Griffithides mesotuberculatus* (M'Coy), from the carboniferous limestone of Bowertrapping, near Dalry, Ayrshire; the cup of an apparently undescribed crinoid from the limestone shale at Williamwood, Cathcart, and a rib and other bones from the blackband ironstone of Quarter, near Hamilton, which he considered belonged probably to *Anthracosaurus*, a coal reptile whose remains occur at Quarter, and in the same beds in the Airdrie district, a few miles to the east.

Mr. JOHN YOUNG made some remarks on Mr. Smith's specimens, and stated that the limestone in which the Trilobite remains are found occupies a high position among the limestones of the Ayrshire coal field, and that they occur in it in greater abundance than has yet been found

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in any other stratum in the west of Scotland. The parts—glabellá, pygidium, cheek-spines, &c., are in general found disarticulated, but well preserved—the eyes being well seen in most specimens; and this condition seems to prevail in all the other localities in Scotland where Trilobite remains occur—perfect examples being very rare.

Mr. WILLIAM CAMERON read a paper on "The Auriferous Rocks and Drifts of Victoria" (p. 117), which he illustrated by the exhibition of specimens of gold and auriferous quartz, and maps of the geological survey of Victoria, presented to him by the Hon. J. F. Sullivan, Minister of Mines, on the occasion of his leaving the colony.

After some remarks by the Chairman, the meeting adjourned.

FEBRUARY 1, 1866.

EDWARD A. WÜNSCH, Esq., *Vice-President*, in the Chair.

The minutes of the previous meeting having been read and confirmed, and thanks voted for donations to the library, the following gentlemen were elected members of the Society, viz.:—as a corresponding member, Rev. Edward Myers, F.G.S., 29 Summerhill Terrace, Birmingham; as resident members—George Birrell, Prospect Bank, Cathcart Road; John Burnet, 150 St. Vincent Street; William Coghill, 263 Argyll Street; Robert Faulds, jun., 61 Parliamentary road; Henry Moore, 49 West George Street; William Moore, 49 West George Street; Robert Spiers, 38 Bath Street.

Robert Dalglish, Esq., and William Graham, Esq., Members of Parliament for the city of Glasgow, were elected life members.

Mr. JOHN SUTHERLAND exhibited a specimen of a peculiar-looking iron ore from Ireland. It has much of the characteristic appearance of plumbago, and leaves a black greasy stain when rubbed between the fingers; is comparatively soft, and gives off under the knife glistening particles of a metallic lustre, not unlike powdered mica. It is quite unacted on by the blowpipe, and contains no carbonaceous matter whatever. A rough analysis gives the following as its composition:—

Ferric Oxide, - - - - - - - - - -	90·5
Matter insoluble in H. C. L. and N. O., - -	9·5
	100·0

The Rev. HENRY W. CROSSKEY exhibited a specimen of *Balanus cariosus* (Darwin), from the well known clay-bed opposite Colintraive, in the Kyles of Bute; and stated that the researches which Mr. David Robertson and himself had been engaged in for some time past result in intensifying the Arctic character of the fauna in the glacial deposits of the west of Scotland. The species is now found living in Davis' Straits.

Mr. R. WHYTE SKIPSEY read a paper on the "Range and Occurrence of *Anthracosia*, and other Shells in the Coal Measures eastward of Glasgow"

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(p. 141), illustrated by a numerous series of specimens of *Anthracosia*, *Anthracoptera*, and *Anthracomya*.

Mr. JOHN YOUNG read "Notes on the occurrence and range of *Lingula* in the Carboniferous Series of the West of Scotland," (p. 144), illustrated by drawings and specimens of the various Scottish species, and recent *Lingula* from the Secretary's collection.

The Rev. HENRY W. CROSSKEY read a paper on "The Relationship between the Fossils of the Glacial Beds of Canada and those of the Clyde," (p. 132). Mr. Crosskey, at same time, exhibited a fine series of shells from the glacial beds of the St. Lawrence, presented to him by Principal Dawson, of Montreal.

The meeting afterwards adjourned.

MARCH 1, 1866.

The Rev. HENRY W. CROSSKEY, *Vice-President*, in the Chair.

The minutes of the previous meeting were read and confirmed, presentations announced, and thanks voted to the donors.

Andrew Simpson MacClelland, 140 St. Vincent Street; John Rattray, 94 Renfield Street; J. G. Reid, 134 Blythswood Terrace; George Simpson, C.E., 172 West George Street, were elected resident members.

Mr. R. Whyte Skipsey, was elected a member of Council in room of Mr. James Sinclair, who had removed from Glasgow.

The SECRETARY read a copy of "Resolutions of Meetings of Representatives from the several Philosophical, Scientific, and Art Societies of Glasgow," requesting the appointment by the Geological Society of a committee to form part of a general committee to consider a scheme for the association of these societies in one building. Messrs. Edward A. Wünsch, the Rev. Henry W. Crosskey, George R. Alexander, and the Secretary were appointed for that purpose.

Mr. JOHN YOUNG exhibited four species of *Foraminifera* which he had lately obtained from some of the limestone shales of the Lanarkshire coal-field, this being the first instance of their occurrence in Scottish carboniferous strata. Two of the forms, he said, were referable to the genus *Textularia*, and appeared to belong to distinct species. They occur in the limestone shales at Brockley, near Lesmahagow, but are not very abundant. One of the forms he had also detected among some specimens sent him for examination by Mr. Hunter of Braidwood, near Carluke, and which he had obtained from the main limestone of that locality. A Rotaline form, from the shales at Calderside, High Blantyre, he had submitted to Professer T. Rupert Jones, who said that it was closely allied to a recent form, *Truncatulina lobatula*; but the carboniferous Foraminifera would require to be more fully investigated before their relation to any recent species can be clearly established. The other species exhibited was a globose Rotaline form, one-half line in diameter, of rare occurrence, in the shales at Brockley, and in the main limestone at Braidwood. Mr. Young remarked that some other minute

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organisms had lately turned up in some of the marine shales, in his search for Entomostraca, and which he was inclined to regard as Foraminifera; but he had not yet been able to investigate their structure. In conclusion, he observed that, as the minute search of our marine limestones and shales went on, other specimens of Foraminifera may be expected to occur in other localities; and he called the attention of members who were investigating the local limestone strata, to search closely for this small but interesting class of fossils, so that the list might be increased.

Mr. R. Whyte Skipsey read a paper on "The Clyde as a River and Firth; its Course, Rocks, and Geological Aspects," in which he stated his belief that since the deposition of the boulder drift, the tidal wave had not reached much, if any, higher than its present limits in the river. At and around Carmyle the gravels were almost entirely the remains of the boulder drift from the north-west, as they were also from thence across the country, through the Kelvin, Campsie, and Blane valleys, which he believed to have been the ancient course of the Clyde from Carmyle to the eastern portion of Loch Lomond, into which it flowed, and thence by the Leven seawards; the present course of the river from Carmyle downwards having been subsequently formed by the silting up of the former, and its waters when in flood forcing a new outlet for it. The author believed the channel of the frith by which the river course, after its junction with the Leven, traversed exclusively the north shore along the Cowal coast, and reached the outer waters through the Kyles of Bute, while the southern shores of the present frith, embracing the whole of the present lowland range, upwards to Paisley, Govan, and to the centre of Glasgow itself, had probably formed a succession of quiet estuaries—the great profusion of Boreal shells suggesting to the author such a conclusion.

Mr. Skipsey's paper was criticised by several of the members, all of whom strongly controverted, both on physical and palæontological grounds, the hypothesis he had suggested; but Mr. Wünsch, in moving a vote of thanks to him for his paper, which was cordially passed, said, that however much they might differ from his conclusions, they could not fail to admire the energy which he had shown, not only in travelling over so much ground and investigating for himself the physical features of the district, but no less so in coming forward with the expression of the opinions he had formed in spite of all the opposition and criticism he might expect to encounter.

Mr. J. Donald Campbell, in a brief verbal statement, submitted for the consideration of the members "Some difficulties in the ordinary theory of the Origin of Species." After some reference to the paper read by Mr. William Keddie last session, he stated, that while he held opinions at variance with those then expressed, he had no intention of entering into a discussion, either of the Transmutation Theory of Darwin, or of the opposite one of the Independent Origin of Species, but merely to state some difficulties which appeared to him objections to the latter, in so far as it did not account for them and to other facts in nature. Mr. Campbell then enumerated a few of the difficulties he had alluded to, such as the distribution of species in time and space, relation of species to each other, and of particular organs of some animals, which were apparently adaptations to

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altered circumstances, rather than specially designed. After stating that recent experiments had conclusively settled in the negative, the theory of spontaneous generation, he said that he did not attempt to account for the difficulties he had stated, but suggested them more as subjects for thought and investigation.

After an animated debate, and the expression of opinions by many of the members, adverse to those suggested by Mr. Campbell, who made an able reply, the Society adjourned.

MARCH 22, 1866.

Mr. R. WHYTE SKIPSEY in the Chair.

Mr. JAMES FARIE, the Secretary, exhibited a specimen of "Wulfenite," or Molybdate of Lead, from the Lochantyre mine, near Gatehouse, Kirkcudbrightshire, a mineral which he believed to be hitherto unknown in Britain. Mr. Farie exhibited also, from the same mine, a specimen of Vanadiate of Copper, new to Britain, and stated in recent works, such as Bristow's and Dana's, to be found only in the Urals.

The SECRETARY read a communication from Mr. James Croll "On the reason why the Change of Climate in Canada since the Glacial Epoch has been less complete than in Scotland" (p. 138).

The Society afterwards adjourned.

APRIL 12, 1866.

Dr. JOHN SCOULER, F.L.S., *Vice-President*, in the Chair.

The minutes of the previous meeting were read and passed. The list of donations was read, and thanks voted to the donors. A fine large photographic portrait, finished in oil, of the venerable President of the Society—James Smith, Esq. of Jordanhill, F.R.S.—was also presented to the Society by a few of the Members who had subscribed for it.

The following gentlemen were admitted Members :—As Life Members—The Hon. John Blackie, jun., Lord Provost, and Neil Robson, Esq., Ironmaster. As Resident Members—David M'Cubbin, West Regent Street; John Crawford, 156 West George Street; Walter Hood, Royal Exchange Square; Duncan Keith, 61 Renfield Street; Duncan M'Laurin, 142 Renfrew Street; R. Carter Moffat, F.R.S.S.A., 108 Ingram Street; G. W. Muir, 58 Renfield Street. And as Corresponding Member—Rev. Paton J. Gloag, Manse, Blantyre.

Mr. James Bennie exhibited part of the forehead and horns of *Bos longifrons* and a horn of *Bos primigenius*, obtained from excavations in streets of the City.

Mr. John Young exhibited several rare and undescribed univalve shells from the carboniferous limestone series of the West of Scotland, as also drawings of them which he had made. They belonged to the genera *Murchisonia*, *Loxonema*, *Macrocheilus*, *Naticopsis*, and *Pleurotomaria*, and

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were a few among a great many species of univalve and other shells, many of them new to Scotland, and others new to science, which had of late been discovered by the persevering and minute examination of the local limestone strata by members of the society.

Mr. JOHN YOUNG read, in the absence of the author, "Notes on the Occurrence of Coal Beds under the Traps of the Bowling Hills," by Mr. Alexander Currie, of Bowling (p. 149).

Mr. JAMES BENNIE read a paper "On the occurrence of *Bos longifrons* and *Bos primigenius* in the ancient drifts of the Clyde" (p. 152).

Dr. SCOULER gave an account and description of the various remains of extinct quadrupeds found in the valley of the Clyde, in the course of which he said that Scotland was poorer than England in such remains. It had none of the cavern animals, such as the Bear, Hyæna, &c., which are so frequent in England, nor has any fragment of the Hippopotamus or Rhinoceros ever been found—the extinct elephant being the only species of this group whose bones have hitherto been got in a few localities in our neighbourhood. There is another series of quadrupeds, however, whose remains are not unncommon in Scotland, such as the *Bos primigenius*, the Reindeer and the Red deer, animals which were the companions of the Elephant in our country, which long survived it, and some of which are not yet extinct. The investigation of these remains acquire something more than geological interest, since the excellent and successful researches of Mr. Bennie respecting the canoe period of the Clyde. It is interesting to know that when these canoes floated on the Clyde many animals roamed in the country which have now disappeared. The early canoemen had to defend themselves from the Bear and the Wolf, and no doubt hunted the Reindeer and the gigantic Ox. Of these animals the remains of the Red deer are, as might be expected, by far the most common. They occur in bogs, in the alluvial soil, and in the river alluvium of the same age as the canoemen. The Reindeer is more rare; but a fine specimen was found near the Endrick several years ago; and Dr. Scouler exhibited a fragment of the horn of this species dredged from the Clyde near Renfrew. The gigantic *Bos primigenius*, which survived in Europe till late in the Roman period, was abundant in Scotland: a fine specimen of the head and horns, exhibited by Dr. Scouler, was found in the Clyde near Renfrew, and another had been found at Rothesay in digging for the foundations for a house. The small extinct ox, *Bos longifrons*, which is not uncommon in Ireland, is rare in Scotland, and, indeed, the only Scottish specimen he had seen was the one discovered by Mr. Bennie. The most ancient quadruped whose remains occur in Scotland is the *Elephas primigenius*. Kilmaurs, near Kilmarnock must have been a great resort of this Mammoth, as he believed no fewer than nine tusks of it had been found there, which would indicate at least five elephants; and it is somewhat remarkable that none of their bones have been found with the exception of a molar found by himself. The horns of the Reindeer were found associated with these remains of the Elephant.

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SUMMER EXCURSIONS—1866.

THE first excursion of the season was made on Saturday, April 28, when a large number of the members, under the guidance of Mr. John Young, left town by the 1·50 p.m. train to Kirkintilloch for a visit to Corrieburn; on the Campsie Fells—a locality which, from the variety of geological phenomena exhibited in the sections of both its eastern and western burns, and its easy access to the members, is perhaps one of the finest for geological field-work in the immediate neighbourhood of Glasgow. It is situated on the hill-side, about a mile and a half to the north of the road leading to Kilsyth, and about two miles north-west from that town. An hour and a half's pleasant walk from Kirkintilloch along the Inchbelly Road brought the party to the hill-side sections of Corrie. These consist in their lowest divisions of beds of trappean (volcanic) ash and greenstone, overlaid by strata of sandstone, limestone, shale, coal, and ironstone, and are well exposed in the sections of the west burn, and along the hill-side between the two burns, where the strata are tilted up at a high angle against the trap which forms the upper part of the hill. The geological position of the Corrie beds is in the lower division of the Carboniferous Limestone series, and the limestones and shales are characterised by an abundance of the peculiar marine organisms of that period—nearly a hundred species of these having already been collected and arranged in the cabinets of members of the society. After examining the beds of Coralline limestone—some sections of which exhibit the beds *in situ*—and collecting some of the fossils, which are here obtained in great profusion and in fine condition, the party proceeded up the west burn, examining the numerous boulders in its bed—an interesting hill-side museum, from which may be selected a great variety of the traps, and igneous rocks of the West of Scotland. These have been washed out of a great deposit of Boulder Clay, which forms the western bank of the stream. Many of these boulders are of great size—one of them, in particular, being estimated at upwards of 50 tons in weight; some of them present very distinct traces of glacial striæ, and are, indeed, among the finest examples of large striated boulders in the district around Glasgow. After examining the altered strata of sandstone, limestone, and shale in contact with the trap rock above the lofty waterfall in the western burn, the party proceeded along the hill-side to the eastward, where a thin vein of sulphate of barytes in the trap crops out. It contains traces of silver and copper, which were once unsuccessfully attempted to be worked. Specimens having been procured, the party reached the eastern burn, where a lofty section of shale, with nodules of clay ironstone, is seen. In passing along the hill-side the sandstones and shales were observed to be much indurated near their junction with the trap rock, proving that the various sedimentary beds of the Corrie had been elevated, disturbed, and altered since the period of their deposition—sandstones being changed into quartzites —limestones into marble, and shales into hornstones. Specimens of agates and jaspers were obtained, one of the party being fortunate in securing a fine specimen of the latter. The various points of geological interest were

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pointed out and explained by Mr. Young; and as the party rested on the hill-side they were favoured, under a clear sky, with a most varied and extensive view:—spread out before them lay the great coal basin of central Scotland, with its undulating heights and cultivated fields; while to the south-west, dimly seen in the distance, Goatfell reared its granite peak over the trappean hills of Ayrshire, which, with the hills of Renfrewshire and Lanarkshire, bounded the view in that direction. Tinto, Culter Fell, and the Pentlands bounded the prospect to the south and east—while the Campsie Fells closed in the view on the north. After a survey of the eastern burn, and collecting a few specimens from the *Pecten* limestone, the party crossed to the farm-steading of Corrie, at the foot of the western burn, where having rested, they with recruited strength made their way, as evening closed, to the Kirkintilloch station, from whence they were speedily carried home, laden with the spoils of their hammers.

On Saturday, May 12, a large number of the members mustered at Bridge Street Railway Station, and proceeded to Paisley by the 2 P.M. train, the programme for this second of their summer excursions being an afternoon's ramble on Gleniffer Braes, a district interesting to the geologist on account of its beds of volcanic ash and greenstone, its zeolitic minerals, and the numerous instances of igneous action which are well displayed in many of the sections exposed at various points on the hill-sides.

The party, under the guidance of Mr. R. W. Skipsey, commenced their explorations by examining a bed of coal, known by the local name of the "Lady Anne" seam, which crops out in the bed of a small stream at the Glenfield Starch Works, and which has been much calcined by an overlying bed of volcanic ash. The position of this coal in the Clydesdale series has been ascertained to be about thirty fathoms below the horizon of the Hurlet coal beds. From this point they directed their steps upwards towards the brow of the hill, passing by the way Tannahill's Well and Craigie Linn, a fine cascade which leaps over a thick mass of greenstone, wearing away in its descent into a hollow recess the underlying softer beds of volcanic ash, a characteristic feature in many of the waterfalls in trappean districts, and especially so in those on the flanks of the Kilpatrick and Campsie ranges. The view from above the Linn is perhaps one of the most extensive in the West of Scotland. Clearly defined against the horizon are seen the noble range of mountains which stretch from the northern portion of Cantyre onwards into Perthshire, and embracing the group known as the "Duke of Argyll's Bowling Green," and the more isolated peaks of the "Cobbler," Ben Lomond, Ben Venue, and others, the bold outlines of which are in marked contrast to the undulating, terrace-like green-fringed fells of Kilpatrick and Campsie, the former at once indicating to the eye of the field-geologist the hills of the metamorphic region of Scotland, composed of sedimentary strata, crumpled and flexured by subterranean heat, the latter the result of lava ejections from volcanoes, and both alike testifying to the stupendous power of long-continued ice and atmospheric action in moulding their present outlines.

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After leaving this spot, the party arrived at a mass of thick-bedded carboniferous limestone, somewhat schistose in character, tilted up by the trap of the hills to an angle of 24 degrees, the dip being to the south, which is again almost reversed on the west side, not many yards distant. The position of this limestone is considered to be above the Hurlet coal. Fossils do not appear to be either abundant or well-preserved, which is doubtless due to the close proximity of the limestone to the trap. A few specimens of Brachiopoda, and one or two examples of *Aviculopecten*, were all that rewarded the search of the most industrious. To the south, the line of one of the hill streams assumes an interesting phase, having cut for itself a rugged course through the trap rocks for nearly three-quarters of a mile, and forming the picturesque gorge of Gleniffer Glen, which is only from ten to fifteen feet wide, with vertical walls of from twenty to thirty feet in height. This gorge, to the student of physical geology, has great attractions; in one part, the trap, in a state of semi-crystalline greenstone, in thin horizontal layers, is intersected by a vertical wall of hard volcanic ash; at another the ash forms the walls, and is pierced vertically by a compact dyke of greenstone; and again the schistose form is seen in a vertical position, cut through by masses of the variety of trap which contains the mineral *Ferrite* in its primitive colour.

The minerals found in the traps of Gleniffer Braes are principally zeolites, and varieties of the red mineral termed *Ferrite*, an analysis of which was given in the Transactions, (Vol. ii. page 36) by Mr. J. Wallace Young.

This mineral in its red state is probably pseudomorphous, and specimens of it were obtained, showing the change from its normal colour of blackish-green into that of bright red.

After a thorough exploration of Gleniffer Glen, which affords great attractions to the botanist as well as to the geologist, the party made their way leisurely along the brow of the hill back to Paisley Station.

On Saturday, June 9, the members made an excursion to High Blantyre and Calder Glen. The day, fine in the morning, dulled at noon, and shortly after settled into a dropping rain which spoiled, in so far as rain could, the pleasure of the excursion; but the members, despite the rain, persisted in their programme, and carried it out.

At High Blantyre they were joined by the Rev. Paton J. Gloag and Dr. James Bryce, F.G.S., members of the society resident in the neighbourhood, who kindly conducted them over the course marked out.

The quarries visited—Newfield and Broomhouse—are situated in a series of well-marked strata, which extends from Stuartfield, about half a mile to the west of East Kilbride Kirk, to Boghead in Hamilton parish, a distance of four or five miles. They have been largely wrought, as the many quarries opened and mines driven into them evidence, and must have supplied the district with lime for hundreds of years. Upwards of seventy years ago they were consecrated to science by the Rev. David Ure, at that time assistant minister of East Kilbride, who, in his "History of Rutherglen and East

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Kilbride," figured and described many of the fossils he found in these quarries, which from that circumstance have been regarded as the prototypes of their species. The Geological Society of Glasgow have worthily followed Ure's example, and in Davidson's monograph of Scottish Carboniferous Brachiopoda the names of these quarries appear repeatedly in his lists of localities.

Arriving at Newfield, the members set to work, and for a time the quarry resounded with the strokes of the hammer. Many specimens were extracted from the matrix, handed round for recognition, named by authority, and carefully packed. Walking through the quarries, the sections and character of the rocks exposed were studied, and as they vary much, and represent extremely diverse conditions in very short space, they excited much interest. First, there is the boulder-clay, twelve feet deep, red in tint, and full of stones, which vary much in size and composition. These are well marked with striæ and other recognisable signs of ice-action—nay, the very surface of limestone beneath is beautifully polished and striated, showing that glaciers had undoubtedly once on a time hurtled over it. The second bed is a coarse open sandstone, eight or ten feet thick, having nothing preserved in it except odd bits of drift-wood here and there, but showing that higher life had once dwelt in the seas in which it was deposited, as the threads of stone that drop from it into the shale beneath must be casts of worm burrows. The third bed is a hard, dry, black shale, eight or ten feet thick, with nothing remarkable in it here, but a string of limestone balls which run into a continuous layer, and form the seam of cement stone wrought in the ground immediately above. The fourth bed is a stratum of limestone, a foot in thickness, of which little noteworthy is known. The fifth, a blueish-grey shale, very earthy in its composition, is full of fossils, and is the great attraction of the locality for geologists. A list of the organic remains would be out of place here, as the species must be reckoned by hundreds, but it may hereafter appear in the Transactions of the Society. The sixth bed is the thick post of limestone for which the quarries are wrought. It is about five feet thick, and is used almost exclusively by the Clyde Ironworks to flux their ironstone. The last bed is not shown in the section, but is seen in a quarry lower down, and consists of a compact yellowish sandstone, remarkable only for the excellence of the grindstones made of it.

Having exhausted the sections, the members proceeded into Calder Glen to look at a notable escarpment which overhangs the Calder, and is supposed to be the "Blackcraig" mentioned by Ure as "140 feet perpendicular, exhibiting thirty distinct strata, about seventeen of which are ironstone." Some doubt of its identity was expressed, as the number of the strata did not tally with Ure's, but all acknowledged it to be a magnificent sight, which fitly closed the day's proceedings.

The party returned to High Blantyre through the beautiful policies of Calderwood; and after partaking of the hospitality of the manse, and spending an hour very instructively, in inspecting Mr. Gloag's collection of fossils illustrative of the various British rock formations, the party returned to Glasgow.

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On Saturday, June 30, the Society made an excursion to Edinburgh, to give the members an opportunity of examining the trap phenomena of that city and its vicinity. Starting from Dundas Street Station at Seven A.M., the members arrived at the Princes Street Station, where Mr. James Haswell, M.A., Hon. Secy. of the Edinburgh Geological Society, met and conducted them to the Society's rooms in St. Andrew's Square. Here a number of the members of the Edinburgh Society had assembled to fraternise with their brethren from the West, and their hospitality was evinced by a substantial breakfast which they had provided in their rooms for the excursionists. At the breakfast, Mr. Page, in the absence of Mr. Charles Maclaren, F.G.S., the venerable president of the society, occupied the chair. This being the first occasion on which the two societies (the only two Geological Societies in Scotland) had met, the party, numbering about forty, proceeded after breakfast to the West Princes Street Gardens, where Mr. Tunny, photographer, took a photograph of the group at the foot of the Castle rock. After inspecting the basaltic clinkstone of this famous rock, and the traces of glaciation seen on its surface at some points, the party walked along the base through the gardens to the corner of Grindlay Street, where a portion of a trap dyke is visible, cutting through the sandstone strata. The next halt was made at the back of the Castle, at the interesting section below the half moon battery, where the basalt has thrown up the shales and sandstones which form the ridge on which part of the Old Town is built. The Calton Hill was the next point of interest—the varied character of the trap-ashes or trap-tuffs, with their enclosed "bombs" of all sizes, up to a foot and a half in diameter, attracting particular attention. From the road below Nelson's Monument the party had a view of Arthur's Seat and the Valley of the Canongate; and Mr. Page, who acted as leader, took the opportunity of pointing out the principal geological features of the district within view. A small lithograph sketch plan of the various trap localities near Edinburgh, which had been prepared for the occasion by Mr. Ferguson, engraver, one of the society's members, and presented by him to each of the party, was here found to be of great service, especially to the Glasgow gentlemen, in enabling them to arrive at a better conception of the position of the trap rocks in relation to one another, and to the surrounding carboniferous strata. From the Calton Hill the party proceeded to Salisbury Crags, where at the north-east end the junction of the greenstone with the overlying strata of sandstone, &c., is so well displayed; then past St. Anthony's chapel, and round the Queen's Drive to Dunsappie. This finished the eastern portion of the hill. The next point was a section of the south side of the Drive, consisting of trap conglomerates and breccias, lying above the interbedded greenstone of the Long Row. Proceeding further west, the first view was obtained of the later ashes, which cap the older traps of the hill. Farther along, the famous groovings and glacial markings on the greenstone at the roadside, which the society were the means of preserving at the time the Drive was being cut, attracted attention and were minutely examined. The next points were the sections of conglomeritic sandstones at the Hawse, and the columnar basalt of Samson's Ribs. As the rain now came on heavily, the party wended their way down the Valley to Holyrood,

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and up to the Waverley Bridge Station, the members of the Glasgow Society leaving by the 4.45 train, after expressing themselves very much gratified with their excursion to Edinburgh, and the anticipation of a return visit to the West by their Edinburgh friends.

DONATIONS TO THE SOCIETY'S LIBRARY,

From October 1, 1865, to September 30, 1866.

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OF GLASGOW.

VOL. II.—PART III.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

SESSION 1866-67.

LVII.—*On the Change in the* Obliquity *of the* Ecliptic; *its Influence on the* Climate *of the* Polar Regions, *and* Level *of the* Sea. By Mr. James Croll.

(Read April 18th, 1867.)

It is now pretty generally admitted by geologists that, during the past geological history of our globe, the northern hemisphere, at least, has passed through several glacial epochs. The existence of an Ice period during the Permian and Upper Miocene epochs, and perhaps during the Middle Eocene also, may now be regarded as established.* And I believe that there are few geologists who have given special attention to the matter who will not admit that we have evidence of the existence of ice-action during the Silurian, Old Red Sandstone, and Cretaceous periods. But what is most remarkable is the fact that, during those very same periods, we have evidence of the existence of a much warmer and more equable condition of climate than prevails at present. And we have also indisputable evidence that this warm and equable condition of climate was not confined to temperate regions, but extended beyond the arctic circle, even up to the highest latitudes that man has yet been able to reach. I shall state briefly a few of the facts to which I allude.

In the arctic regions, encrinites, corals, and mollusca, belonging to the Silurian period, have been found in abundance,† proving

* Lyell's "Principles," New Edition. Vol. i., chaps. x. and xi.

† Quart. Journ. Geol. Soc., Vol. xi., p. 510.

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that a warm sea must have prevailed in those regions during, at least, a part of that age. It is well known that all over the arctic regions, extending to the most northern limit that has yet been attained, coal and carboniferous limestone have been found in abundance. And the existence of magnesian limestone in high latitudes seems to indicate that, also during a part of the Permian period, a warm sea must have reached to arctic regions. We have evidence of a warm condition of climate in North Greenland during the Oolitic period. For example, in Prince Patrick's Island, at Wilkie Point, in lat. 76° 20′ N., and long. 117° 20′ W., Oolitic rocks containing an ammonite (*Ammonites M'Clintocki*, Haughton), like the *Ammonites concavus* and other shells of the Oolitic species, were found by Captain M'Clintock.* In Katmai Bay, near Behring's Straits, the following Oolitic fossils were found:—*Ammonites Wossnessenskii*, *Ammonites biplex*, *Belemnites paxillosus*, and *Unio liassinus*.† Sir E. Belcher found in Exmouth Island, lat. 77° 16′ N., and long. 96° W., at an elevation of 570 feet above the level of the sea, bones which were examined by Prof. Owen, and pronounced to be those of the *Ichthyosaurus*.‡ Mr. Salter remarks that, at the time that these fossils were deposited, "a condition of climate something like that of our own shores was prevailing in latitudes not far short of 80° N."‖ And Mr. Jukes says that, during the Oolitic period, "in latitudes where now sea and land are bound in ice and snow throughout the year, there formerly flourished animals and plants similar to those living in our own province at the time. The question thus raised," continues Mr. Jukes, "as to the climate of the globe when cephalopods and reptiles, such as we should expect to find only in warm or temperate seas, could live in such high latitudes, are not easy to answer.§ When we come to examine the arctic flora of the Upper Miocene period, we find that North Greenland and the entire polar regions at that period enjoyed a condition of climate as warm as that of England at the present day. "We know," says Sir Charles Lyell, "that Greenland was not always covered with snow and ice; for when we examine the tertiary

* Journ. of the Royal Dublin Soc. for February, 1857.

† Quart. Journ. Geol. Soc., Vol. xi., p. 519.

‡ The Last of the Arctic Voyages, by Captain Sir E. Belcher, Vol. II., p. 389, Appendix.

‖ Quart. Journ. Geol. Soc., Vol. ii., p. 379.

§ Manual of Geology, pp. 395, 493.

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strata of Disco Island, we discover there a multitude of fossil plants, which demonstrate that, like many other parts of the arctic regions, it formerly enjoyed a mild and genial climate." *

At the meeting of the British Association held at Nottingham in August last, Prof. Heer read a valuable paper on the Miocene Flora of North Greenland. In this paper some remarkable conclusions as to the probable temperature of Greenland during the Miocene period were given. Upwards of sixty different species brought from Atanekerdluk, a place on the Waigat opposite Disco, in lat. 70° N., has been examined by him.

A steep hill rises, he says, on the coast to a height of 1080 feet, and at this level the fossil plants are found. Large quantities of wood in a fossilized or carbonized condition lie about. Captain Inglefield observed one trunk thicker than a man's body standing upright. The leaves, however, are the most important portion of the deposit, and give a most valuable insight into the nature of the vegetation which formed this primæval forest. In regard to those fossilized plants, he concludes that they cannot have been drifted from any great distance. They must have grown on the spot where they are found; and they prove, without a doubt, that North Greenland, in the Miocene epoch, had a climate much warmer than its present one. He states that it is quite impossible that the trees found at Atanekerdluk could ever have flourished there if the temperature were not far higher than at present. The difference must have been at least 29° F. Nor were the trees found here all at the extreme northern limit of their growth; for in the Miocene flora of Spitzbergen, lat. 78° N., we find the beech, plane, hazel, and some other species identical with those from Greenland. And we may conclude, he thinks, that the firs and poplars which we meet at Atanekerdluk and Bell Sound, Spitzbergen, must have reached up to the North Pole if land existed there in the Tertiary period.

The *Sequoia Longsdorfii* is the most abundant of the trees of Atanekerdluk. The *Sequoia sempervirens* is its present representative. This tree has its extreme northern limit about lat. 53° N. For its existence it requires a summer temperature of 59° or 61°. Its fruit requires a temperature of 64° for ripening. The winter temperature must not fall below 34°, and that of the whole year must be at least 49°. The temperature of Atanekerdluk

* Antiquity of Man, Second Edition, p. 237.

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during the time that the Miocene flora grew could not have been under the above. "These conclusions," says Professor Heer, "are only links in the grand chain of evidence obtained from the examination of the Miocene flora of the whole of Europe. They prove to us that we could not by any re-arrangement of the relative positions of land and water produce for the northern hemisphere a climate which would explain the phenomena in a satisfactory manner. We must," he continues, "admit that we are face to face with a problem whose solution in all probability must be attempted, and, we doubt not, completed by the astronomer."

But, more singular still, at a period not anterior at least to that of the boulder-clay, a condition of climate prevailed in arctic regions much warmer than at present; for the remains of ancient forests have been found in places where at present nothing is to be found but fields of snow and ice, and where the mean annual temperature scarcely rises above the zero of the Fahrenheit thermometer.

A trunk of a tree was discovered erect as it grew, by Captain Sir E. Belcher on the 12th of September, 1853, to the north of a narrow strait which opens into Wellington Sound, lat. 75° 32′ N., long. 92° W. The trunk was dug up and brought to England and examined by Dr. Hooker, who pronounced it to be a species of white spruce, *Pinus (Abies) alba.** The remains of an ancient forest was discovered by Captain M'Clure in Banks' Land, in lat. 74° 48′, extending along a range of hills varying from 350 to 500 feet above the sea, and from half a mile to upwards, inland. He found a great accumulation of fossil trees as well as fragments not fossilized lying over the whole extent of the land. "This remarkable phenomenon," says Captain M'Clure, "opens a vast field for conjecture, and the imagination becomes bewildered in trying to realize that period of the world's history where the absence of ice and a milder climate allowed forest trees to grow in a region where now the ground-willow and dwarf-birch have to struggle for existence."† Trunks of trees, some of them 3 feet in circumference, have been found in Prince Patrick's Island and Melville Island on the spot in which they grew. This place is perhaps at present the coldest spot in the northern hemisphere.

It is true that Sir Roderick Murchison‡ had at one time stated

* British Association Report for 1855, p. 101.
† Discovery of a North-west Passage, p. 208.
‡ Quart. Journ. Geol. Soc., Vol. xi., p. 540.

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it to be his opinion that those vast quantities of wood found in arctic regions were drifted to their present positions at a period when those regions were submerged. This opinion is now, I believe, generally abandoned.

But the most remarkable circumstance, and certainly the most unaccountable of all, upon the ordinary theories of change of climate during geological epochs, is the fact that we have not only had a succession of cold and warm periods, but cold and warm periods occurring in the same epoch. For example, during the Permian period we have not only evidence of a cold period when glaciers even in our own island reached to the sea-level,* but we have also evidence, as we have seen, of a warm condition of climate extending during that epoch even to the arctic regions. And during the Upper Miocene period we find a cold climate prevailing and glaciers descending to the sea-level in the latitude of Italy;† while during another part of this period we know that the climate of the northern hemisphere was much warmer than at present, and Greenland free of ice and covered with a rich and luxuriant flora reaching up to perhaps the North Pole. Again, during the Pliocene period, we have the well-known glacial epoch with the northern hemisphere to considerably low latitudes enveloped in one general capping of ice. And recent discoveries in arctic regions show that at that very period, or perhaps at a period somewhat later, huge forests flourished in North Greenland and the regions about Melville Island, where at present not a shrub can grow, and where nothing is to be seen but interminable fields of snow and ice.

How are these extraordinary changes of climate to be accounted for? We require a cause of not only wide influence but of great intensity of action. In short, a cause which can at one time confer on Greenland, Siberia, and the entire arctic regions the mild climate of England or Maderia, and at another time bury England and nearly the entire temperate regions under perpetual snow and ice. And it must be able not only to do this, but to do it during the continuance of one epoch. There are few, I presume, who can seriously entertain the opinion that these changes can be satisfactorily accounted for without having reference to cosmical agency. When we view the matter from a purely physical and cosmical stand point,

* Quart. Journ. Geol. Soc., Vol. xi., p. 197.

† Lyell's "Principles," Vol. i., p. 207. Memoirs of Royal Academy of Sciences of Turin, second series, Vol. xx.

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we at once perceive that those changes, extreme as they no doubt appear, are in reality what we ought *à priori* to conclude must have occurred. I feel persuaded that those very conclusions to which geologists have been led regarding the changes of climate during past ages, would ultimately have all been arrived at through purely cosmical and physical considerations, even although geology as a science had not existed; they follow so obviously from theory.

It follows as a necessary conclusion that, when the excentricity of the earth's orbit reaches a very high value, the hemisphere which has its winter occurring in aphelion will be under a glacial condition, while the other hemisphere, having its winter in perihelion, will be enjoying a warm and equable climate. And the occurrence at times of cold and warm conditions of climate during the same geological epoch is, in fact, a necessary result of the precession of the equinoxes combined with that of excentricity.

There is still another cause which, I feel convinced, must to a very considerable extent have affected climate during past geological ages. I refer to the change in the Obliquity of the Ecliptic. This cause has long engaged the attention of geologists and physicists; and the conclusion generally arrived at, like that which had been arrived at in regard to excentricity, is that no great effect can be attributed to it. After giving special attention to the matter, I have been led to the very opposite conclusion. It is quite true, as has been urged, that the changes in the obliquity of the ecliptic cannot sensibly affect the climate of temperate regions; but it will produce a slight change on the climate of the tropical regions, and a very considerable effect on that of the polar regions, especially at the poles themselves. We shall now consider the matter briefly.

It was found by Laplace that the obliquity of the ecliptic will oscillate to the extent of 1° 22′ 34″ on each side of 23° 28′, the obliquity in the year 1801. This change will but slightly affect the climate of the temperate regions, but it will exercise a very considerable influence on the climate of the polar regions. According to Mr. Meech,* if 365·24 thermal days represent the present total annual quantity of heat received at the equator from the sun, 151·59 thermal days will represent the quantity received at the poles. Adopting his method of calculation, it turns out that when the obliquity of the ecliptic is at its maximum, viz., at 24° 50′ 34″, the quantity received at the equator would be 363·51

* Smithsonian Contributions to Knowledge, Vol. ix.

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thermal days, and at the poles 160·04 thermal days. The equator would therefore receive 1·73 thermal days less heat, and the poles 8·45 thermal days more heat than at present.

ANNUAL AMOUNT OF SUN'S HEAT.

Amount in 1801. Obliquity 23° 28′.		Amount at maximum, 24° 50′ 34″.	Difference.
Latitude.	Thermal days.	Thermal days.	Thermal days.
0	365·24	363·51	—1·73
40	288·55	288·32	—0·23
70	173·04	179·14	+6·10
80	156·63	164·63	+8·00
90	151·59	160·04	+8·45

When the obliquity was at a maximum, the poles would therefore be receiving 19 rays for every 18 they are receiving at present. The poles would then be receiving nearly as much heat as latitude 76° is receiving at present.

The increase of obliquity would not sensibly affect the polar winter. It is true that it would slightly increase the breadth of the frigid zone, but the length of the winter at the poles would remain unaffected. After the sun disappears below the horizon his rays are completely cut off, so that a further descent of 1° 22′ 34″ would make no material difference whatever in the climate. In the temperate regions the sun's altitude at the winter solstice would be 1° 22′ 34″ less than at present. This would slightly increase the cold of winter in those regions. But the increase in the amount of heat received by the polar regions would materially affect the condition of the polar summer. What, then, is the rise of temperature at the poles which would result from the increase of 8·45 thermal days in the total amount received from the sun?

An increase of 8·45 thermal days, or $\frac{1}{18}$ of the total quantity received from the sun, according to the mode of calculation adopted in a former paper,* would produce, all other things being equal, a rise in the mean annual temperature equal to 14° or 15°.

According to Professor Dove† there is a difference of 7°·6 between the mean annual temperature of lat. 76° and the pole; the

* Phil. Mag. for February, 1867. Lyell's 'Principles,' Vol. i., p. 294.

† Distribution of Heat on the Surface of the Globe, p. 14.

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temperature of the former being 9°·8, and that of the latter 2°·2. Since it follows that when the obliquity of the ecliptic is at a maximum the poles would receive about as much heat per annum as lat. 76° receives at present, it may be supposed that the temperature of the poles at that period ought to be no higher than that of lat. 76° at the present time. A little consideration will, however, show that this by no means ought to be the case. Professor Dove's Tables represent correctly the mean annual temperature corresponding to every tenth degree of latitude from the equator to the pole. But it must be observed that the rate at which the temperature diminishes from the equator to the pole is not proportionate to the decrease in the total quantity of heat received from the sun as we pass from the equator to the pole. Were the mean annual temperature of the various latitudes proportionate to the amount of direct heat received, the equator would be much warmer than it actually is at present, and the poles much colder. The reason of this is perfectly obvious. There is a constant transference of *heat* from the equator to the poles, and of *cold* from the poles to the equator. The warm water of the equator is constantly flowing towards the poles, and the cold water at the poles is constantly flowing to the equator. The same is the case in regard to the aërial currents. Consequently a great portion of the direct heat of the sun goes, not to raise the temperature of the equator, but to heat the poles. And, on the other hand, the cold materials at the poles are transferred to the equator, and thus lower the temperature of that part of the globe to a great extent. The present difference of temperature between lat. 76° and the pole, determined according to the rate at which the temperature is found to diminish between the equator and the pole, amounts to only about 7° or 8°. But were there no mutual transference of warm and cold materials between the equatorial and polar regions, and the temperature of each latitude to depend solely upon the direct rays of the sun, the difference would far exceed that amount.

Now, when the obliquity of the ecliptic was at its superior limit, and the poles receiving about $\frac{1}{18}$ more direct heat from the sun than at present, the increase of temperature due to this increase of heat would be far more than 7° or 8°. It would probably be nearly double that amount.

The enormous effect that ocean-currents have in equalizing the temperature of our globe by diminishing the difference between

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the temperature of the equator and the poles, has never been duly estimated. This will be seen if we merely consider for a moment the effect produced by one current alone, viz., the Gulf-stream. The total quantity of water conveyed by this stream is probably equal to that of a stream 50 miles broad and 1000 feet deep, flowing at the rate of 4 miles an hour. And the mean temperature of the entire mass of moving water is not under 65° at the moment of leaving the Gulf.* I think we are warranted to conclude that the Gulf-stream, before it returns from its northern journey, is on an average cooled down at least 25°. Each cubic foot of water, therefore, in this case carries from the tropics upwards of 1500 units of heat, or 1,158,000 foot-pounds. According to the above estimate of the size and velocity of the stream, 5,575,680,000,000 cubic feet of water are conveyed from the Gulf per hour, or 133,816,320,000,000 cubic feet daily.† Consequently the total quantity of heat transferred from the equatorial regions per day by the stream amounts to 154,959,300,000,000,000,000 foot-pounds. From observations made by Sir John Herschel and by M. Pouillet on the direct heat of the sun, it is found that were no heat absorbed by the atmosphere, about 83 foot-pounds per second would fall upon a square foot of surface placed at right angles to the sun's rays.‡ Mr. Meech estimates that the quantity of heat cut off by the atmosphere is equal to about 22 per cent. of the total amount received from the sun. M. Pouillet estimates the loss at 24 per cent. Taking the former estimate, 64·74 foot-pounds per second will therefore be the quantity of heat falling on a square foot of the earth's surface when the sun is in the zenith. And were the sun to remain stationary in the zenith for twelve hours, 2,796,768 foot-pounds would fall upon the surface.

It can be shown that the total amount of heat received upon a unit-surface on the equator during the twelve hours from sunrise till sunset at the time of the equinoxes is to the total amount

* Phil. Mag. for February 1867, p. 127.

† Captain Maury considers the Gulf-stream equal to a stream 82 miles broad and 1200 feet deep, flowing at the rate of five knots (38,415 feet) an hour (Physical Geography of the Sea, § 24). This gives 6, 166,700,000,000 cubic feet per hour as the quantity of water conveyed by this stream. Sir John Herschel's estimate is still greater. He considers it equal to a stream 30 miles broad and 2200 feet deep, flowing at the rate of four miles an hour (Physical Geography, § 54). This makes the quantity 7,359,900,000,000 cubic feet per hour. Sir John estimates the temperature at 86° F.

‡ Trans. of Royal. Soc. of Edin., Vol. xxi., p. 57. Phil. Mag. S. 4., Vol. ix., p. 36.

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which would be received upon that surface, were the sun to remain in the zenith during those twelve hours, as the diameter of a circle to half its circumference, or as 1 to 1,5708. It follows, therefore, that a square foot of surface on the equator receives from the sun at the time of the equinoxes 1,780,474 foot-pounds daily, and a square mile 49,636,750,000,000 foot-pounds daily. But this amounts to only $\frac{1}{3,121,870}$ part of the quantity of heat daily conveyed from the tropics by the Gulf-stream. In other words, the Gulf-stream conveys as much heat as is received from the sun by 3,121,870 square miles of surface at the equator. The amount thus conveyed is equal to all the heat which falls within 63 miles on each side of the equator. According to calculations made by Mr. Meech, the annual quantity of heat received by a unit-surface on the frigid zone, taking the mean of the whole zone, is $\frac{5 \cdot 4 5}{1 5}$ of that received at the equator. Consequently the quantity of heat conveyed by the Gulf-stream in one year is equal to the heat which falls on an average on 6,873,800 square miles of the arctic regions. The frigid zone or arctic regions contain 8,130,000 square miles. There is actually, therefore, nearly as much heat transferred from the tropical regions by the Gulf-stream as is received from the sun by the entire arctic regions; the quantity conveyed by the stream to that received from the sun by those regions being as 15 to 18.

But we have been assuming in our calculations that the percentage of heat absorbed by the atmosphere is no greater in polar regions than it is at the equator, which is not the case. If we make due allowance for the extra amount absorbed in polar regions in consequence of the obliqueness of the sun's rays, the total quantity of heat conveyed by the Gulf-stream will probably nearly equal the amount received from the sun by the entire arctic regions.

It may be stated, however, that the extra amount of heat absorbed in polar regions in consequence of the oblique direction in which the rays pass through the atmosphere is not nearly so great as is generally represented. It is commonly assumed that the quantity of heat absorbed by the atmosphere is proportionate to the number of aërial particles that the rays have to encounter before reaching the surface of the earth. It is stated as a general rule that if the tracts of the rays follow an arithmetical progression, the diminished force with which the rays reach the ground will form a decreasing geometrical progression. But recent discoveries

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in regard to the absorption of radiant heat by gases and vapours prove that tables computed on this principle must be wholly erroneous. The researches of Tyndall and Melloni show that, when a ray passes through any substance, the absorption is rapid at first, but the ray is soon "sifted," as it is called, and it then passes onwards with but little further obstruction.

In the article on climate in the *Encyclopædia Britannica*, where the calculations are made upon the foregoing principles, it is stated that the annual intensity of the sun's heat at the equator to that at the poles is as 115 to 14, or as 8 to 1 nearly. If the quantity of heat received from the sun by polar regions was actually as small as the writer of this article states, it would follow that the quantity conveyed by the Gulf-stream from the equatorial regions was equal to about three times all that falls within the arctic circle.

It is true that a very considerable part of the heat thus transferred by currents from the equator never reaches the arctic regions. But it nevertheless goes to lower the temperature of the equator and raise the temperature of the higher latitudes. Let it be remembered that our calculations refer only to one single current, the Gulf-stream. If we take into account all the currents which flow from the equatorial regions of our globe, we should find that their influence in reducing the difference between the temperature of equatorial and polar regions is enormous.

A similar function is also performed by aërial currents. The equatorial regions are cooled to a great extent by an aërial current continually flowing from the polar regions to the equator. And the polar regions at least are warmed by an upper current flowing from the torrid and temperate regions towards the poles. The equator is also cooled to a very great extent by *convection*. The hot surface of the ground at the equator transfers its heat to the air, and an ascending current is generated, which carries the heat upwards and dissipates it into stellar space.

It is very probable that were it not for the combined effect of all those causes, the difference of temperature between the equator and the poles would amount to at least 200° instead of about 80°, as at present. Did the earth possess neither an atmosphere nor seas, and were the temperature of each place to depend entirely on the direct heat of the sun, the difference of mean annual temperature between the equator and the poles, according to theory, ought to amount to about 200°.

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We may, therefore, conclude that when the obliquity of the ecliptic was at a maximum, and the poles receiving $\frac{1}{18}$ more heat than at present, the temperature of the poles ought to have been about 14° or 15° warmer than at the present day, *provided, of course, that this extra heat was employed wholly in raising the temperature.* Were the polar regions free from snow and ice, the greater portion of the extra heat would go to raise the temperature. But as those regions are covered with snow and ice, the extra heat would have no effect in raising the temperature, it would simply melt the snow and ice. The ice-covered surface upon which the rays fell could never rise above 32°. At the period under consideration, the total annual quantity of ice melted at the poles would be $\frac{1}{18}$ more than at present.

The general effect which the change in the obliquity of the ecliptic would have upon the climate of the polar regions when combined with the effects resulting from the excentricity of the earth's orbit would be this:—When the excentricity was at a very high value, the hemisphere whose winter occurred in the aphelion (for physical reasons, which have already been discussed at considerable length)* would be under a condition of glaciation, while the other hemisphere, having its winter in perihelion, would be enjoying a warm and equable climate. When the obliquity of the ecliptic was at a maximum, and $\frac{1}{18}$ more heat falling at the poles that at present, the effect would be to modify to a great extent the rigour of the glaciation in the polar zone of the hemisphere under a glacial condition, and, on the other hand, to produce a more rapid melting of the ice on the other hemisphere enjoying the equable climate. The effects of excentricity and obliquity thus combined would probably completely remove the polar ice-cap from off the latter hemisphere, and forest-trees might then grow at the pole. Again, when the obliquity was as its minimum condition and less heat reaching the poles than at present, the glaciation of the former hemisphere would be increased and the warmth of the latter diminished.

One very remarkable effect which seems to result indirectly from a variation of the obliquity under certain conditions, is an influence on the level of the sea. As this probably may have had something to do with those recent changes of sea-level which the history of the submarine forests and raised beaches have made us

* Phil. Mag. for August, 1864 and February, 1867.

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all so familiar with, it may be of interest to enter at some length into this part of this subject.

It appears almost certain that at the time when the northern winter solstice was in the aphelion last, a rise of the sea on the northern hemisphere to a considerable number of feet must have taken place from the combined effect of excentricity and obliquity. About 11,700 years ago the northern winter solstice was in the aphelion. The excentricity at that time was ·0187, being somewhat greater than it is now; but the winters occurring in aphelion instead of perihelion, as at present, they would on this account be probably 10° or 15° colder than they are at the present day. It is probable, also, for reasons formerly stated,* that the Gulf-stream at that time would be considerably less than at present. This would tend to lower the temperature to a still greater extent. As snow must have fallen during winter instead of rain, this no doubt would have produced a slight increase in the quantity of ice on the northern hemisphere had no other cause come into operation. But the condition of things, we have every reason to believe, must have been affected by the greater obliquity of the ecliptic at that period. We have no formula from which we can determine with perfect accuracy the extent of the obliquity at a period so remote as the one under consideration. If we adopt the formula given by Struve and Peters, we have the obliquity at a maximum about the time that the solstice-point was in the aphelion. The formula given by Leverrier places the maximum somewhat later. At all events we cannot be far from the truth in assuming that at the time the northern winter solstice was in the aphelion, the obliquity of the ecliptic would be about a maximum, and that since then it has been gradually diminishing. It is evident, then, that the annual amount of heat received by the arctic regions, and especially about the pole, would be considerably greater than at present. And as the heat received on those regions is chiefly employed in melting the ice, it is probable that the extra amount of ice which would then be melted in the arctic regions would prevent that slight increase of ice which would otherwise result in consequence of the winter occurring in the aphelion. The winters at that period would be colder than they are at present, but the total quantity of ice on the northern hemisphere would not probably be greater. Let us now turn to the southern hemisphere. As

* Phil. Mag. for August, 1864 and February, 1867.

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the southern winter would then occur in the perihelion, it would tend to produce a slight decrease in the quantity of ice on the southern hemisphere. But on this hemisphere the effects of excentricity would not, as on the northern hemisphere, be compensated by those of obliquity; for both causes would here tend to produce the same effect, namely, a melting of the ice in the antarctic regions.

It is probable that at this time the quantity of warm water flowing from the equatorial regions into the Southern Ocean would be much greater than at present. This would tend to raise the temperature of the air of the antarctic regions, and thus assist in melting the ice. These causes, combined with the great increase of heat resulting from the change of obliquity, would tend to diminish to a considerable extent the quantity of ice on the southern hemisphere. I think we may assume that the slight increase of excentricity at that period, the occurrence of the southern winter in perihelion, and the extra quantity of warm water flowing from the equatorial to the antarctic regions would produce an effect on the south polar ice-cap equal to that produced by the increase in the obliquity of the ecliptic. It would, therefore, follow that for every eighteen pounds of ice melted annually at present at the south pole twenty pounds would then be melted.

Let us now consider the effect that this condition of things would have upon the level of the sea. It would evidently tend to produce an elevation of the sea-level on the northern hemisphere in two ways. 1st. The addition to the sea occasioned by the melting of the ice from off the antarctic land would tend to raise the general level of the sea. 2ndly. The removal of the ice would also tend to shift the earth's centre of gravity to the north of its present position—and as the sea must shift along with the centre, a rise of the sea on the northern hemisphere, would necessarily take place.

The question naturally suggests itself, might not the last rise of the sea, relative to the land, have resulted from this cause? We know that during the period of the 25-feet beach, the time when the estuarine mud, which now forms the rich soil of the Carses of the Forth and Tay, was deposited, the sea, in relation to the land, stood at least 20 or 30 feet higher than at present. But immediately prior to this period we have the age of the submarine forests and peat-beds, when the sea relative to the land stood lower than it does at present. We know also that these changes of level were not a

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mere local affair. There seems every reason to believe that our Carse clay, as Mr. Fisher states, is the equivalent of the marine mud, with *Scrobicularia*, which covers the submarine forests of England.* And on the other hand, those submarine forests are not confined to one locality. "They may be traced," says Mr. Jamieson, "round the whole of Britain and Ireland, from Orkney to Cornwall, from Mayo to the shores of Fife, and even, it would seem, along a great part of the western sea-board of Europe, as if they bore witness to a period of wide-spread elevation, when Ireland and Britain, with all its numerous islands, formed one mass of dry land, united to the continent, and stretching out into the Atlantic."† "These submarine forests," remarks De la Beche, also, "are to be found under the same general condition from the shores of Scandinavia to those of Spain and Portugal, and around the British islands."‡ Those buried forests are not confined to Europe, but are found in the valley of the Mississippi and in Nova Scotia, and other parts of North America. And again, the strata which underlie those forests and peat-beds bear witness to the fact of a previous elevation of the sea-level. In short, we have evidence of a number of oscillations of sea-level during post-tertiary times.§

Had there been but only one rise of the land relative to the sea-level, or one depression, it might quite reasonably have been attributed to an upheaval or a sinking of the ground, occasioned by some volcanic, chemical, or other agency. But certainly those repeated oscillations of sea-level, extending as they do over so wide an area, look more like a rising and sinking of the sea than of the land. But, be this as it may, since it is now established, I presume, beyond controversy, that the old notion that the general level of the sea remains permanent, and that the changes must be all attributed to the land is wholly incorrect, and that the sea, as well as the land, is subject to changes of level, it is certainly quite a legitimate subject of inquiry to consider whether the last elevation of the sea-level relatively to the land may not have resulted from the rising of the sea rather than from the sinking of the land. In short,

* Quart. Journ. Geol. Soc., June, 1866, p. 564.

† Quart. Journ. Geol. Soc., Vol. xxi., p. 186.

‡ Geological Observer, p. 446. See also Mr. James Geikie's valuable Memoir "On the Buried Forests and Peat Mosses of Scotland." Trans. of the Royal Society of Edinburgh, Vol. xxiv., and Chambers' Ancient Sea-Margins.

§ See Lyell's "Antiquity of Man," second edition, p. 282; "Elements," sixth edition, p. 162.

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whether it may not be attributed to the cause we are now considering. The fact that those raised beaches and terraces are found at so many different heights, and also so discontinuous along our coasts, might be urged as an objection to the opinion that they were due to changes in the level of the sea itself. Space will not permit of us entering upon the discussion of this point at present; but it may be stated that this objection is more apparent than real. It by no means follows that beaches of the same age must be at the same level. This has been shown very clearly by Mr. W. Pengelly in a paper on "Raised Beaches," read before the British Association at Nottingham last year.

We have, I presume, evidence amounting to almost absolute certainty that 11,700 years ago the general sea-level on the northern hemisphere must have been higher than at present. And in order to determine the question of the 25-feet beach, we have merely to consider whether a rise to something like this extent probably took place at the period in question. We have at present no possible means of knowing with certainty the extent of the rise which must have taken place at that period, for we have no means of ascertaining what was the quantity of ice which must have then been melted off the antarctic regions. But we have the means of making a very rough estimate, which, at least, may enable us to determine whether a rise of some 20 or 30 feet may not possibly have taken place. The principal difficulty which meets us is the uncertainty that still prevails regarding the amount of land within the antarctic circle. As to the existence of an antarctic continent there are, I presume, few well informed on the subject who entertain a doubt, whatever their views may be regarding its extent. If we examine the matter carefully, we shall find that we have every reason to believe that this continent extends, on an average, down to about latitude 70° S. It is only at a very few points that voyagers have been able to penetrate the "pack" and reach to anything like high latitudes. But it has been found that wherever a high latitude was reached *land was generally seen.* For example, lat. 66° 30′ was reached by M. D'Urville in long. 140°, and Adelie Land was found. Lat. 65° was reached by Balleny in long. 120° E., and Sabrina Land was found. Lat. 67° was reached by Biscoe, in long. 60° and 50° E., and Kemp Land and Enderby Land were found. Lat. 63° and 68° were reached by Biscoe, between long. 60° and 70° W., and Graham Land was found. In the year 1774 Capt. Cook reached

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lat. 71° 10′, in long. 106° 54′ W., and saw to the south a very extensive field of ice. And he at the time expressed it as his opinion that the ice covered a continent reaching to the south pole.* About long. 180° Victoria Land was discovered, and the great ice-barrier attached to it, traced by Sir James Ross for several hundreds of miles. A perpendicular wall of ice, similar to that described by Sir James Ross, had been previously traced by the United States Exploring Expedition under Capt. Wilkes, from near the longitude of Victoria Land, in lat. 65°, along in the direction of Enderby Land, for a distance of upwards of 1500 miles. Along this extended coast-line nothing in the shape of an open strait, or of a current in a northerly direction, was found, which seems to show, as Capt. Wilkes remarks, that the ice-barrier must be attached to an unbroken tract of land.†

It is extremely probable that these various tracts of land are but different parts of one great continent extending to the south pole. If they are islands, it is singular that none of them have been circumnavigated. Besides, were they merely islands, it is difficult to conceive how there should be such prodigious masses of icebergs on the southern hemisphere, extending down in all directions to such comparatively low latitudes. If those various tracts of land are parts of one great continent, then this continent will, on an average, extend down to lat. 70°. I may mention that Sir Charles Lyell, who has given much attention to this subject, has, in his late edition of the "Principles," represented the antarctic continent as extending down to about lat. 70°.

One thing, however, is certain, that this continent, whatever its extent may be, is covered with a vast sheet of ice. This sheet is known to be upwards of 1000 feet thick at its edges. And there are reasons of a mechanical nature which will come under our notice perhaps on a future occasion, which prove that the thickness of the sheet in the centre of this continent must be enormous.

Assuming then, that the southern ice-cap extends on an average down to lat. 70°, it will therefore be equal to $\frac{1}{33.163}$ of the entire surface of the globe. The proportion of land to that of water, taking into account the antarctic continents, according to Mr. Saunder,‡

* Cook's Voyages, Vol. ii., p. 86.

† Narrative of United States Exploring Expedition, Whittaker and Co., London.

‡ Lyell's "Principles," Vol. i., p. 257.

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is as 526 to 1272. The Southern ice-cap will therefore be equal to $\frac{1}{23.46}$ of the area covered by water. The density of ice to that of water being taken at ·92 to 1, it follows that 25 feet 6 inches of ice melted from off the face of the antarctic continent would raise the level of the ocean 1 foot. If 470 feet were melted off—and this is by no means an extravagant supposition, when we reflect that for every 18 pounds of ice presently melted an additional pound or two pounds, or perhaps more, would then be melted, and that for many ages in succession—the water thus produced from the melted ice would raise the level of the sea 18 feet 5 inches. The removal of the 470 feet of solid ice—which must be but a very small fraction of the total quantity of ice lying upon the antarctic continent—would shift the earth's centre of gravity about 7 feet to the north of its present position. The shifting of the centre of gravity would cause the sea to sink on the southern hemisphere and rise on the northern.* And the quantity of water thus transferred from the southern hemisphere to the northern, would carry the centre of gravity about 1 foot further, and thus give a total displacement of the centre to the extent of about 8 feet. The sea would therefore rise about 8 feet at the North Pole, and in the latitude of Glasgow about 6 feet 7 inches. This, added to the rise of 18 feet 5 inches, occasioned by the melting of the ice, would give 25 feet as the total rise in the latitude of Scotland 11,700 years ago.

Each square foot of surface at the poles 11,700 years ago, would be receiving 18,223,100 foot-pounds more of heat annually than at present. If we deduct 22 per cent. as the amount absorbed in passing through the atmosphere, we have 14,214,000 foot-pounds. This would be sufficient to melt 2·26 feet of ice. But if 50 per cent. were cut of instead of 22 per cent., 1·45 cubic feet would be melted. In this case the 470 feet of ice would be melted independently of the effects of excentricity, in about 320 years. And supposing that only one-fourth part of the extra heat reached the ground, 470 feet of ice would be removed in about 640 years.

As to the exact time that the obliquity was at a maximum, previous to that of 11,700 years ago, our uncertainty is still greater. If we are permitted to assume that the ecliptic passes from its maximum to its minimum state and back to its maximum again with anything like uniformity, at the rate assigned by Leverrier and others, the obliquity would not be far from a maximum about

* Phil. Mag. for April, 1866.

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60,000 years ago. Taking the rate of precession at 50″.21129, and assuming it to be uniform—which it probably is not—the winter solstice would be in the aphelion about 61,300 years ago.* In short, it seems not at all improbable that at the time the solstice-point was in the aphelion, the obliquity of the ecliptic would not be far from its maximum state. But at this time the value of the excentricity was 0·023, instead of 0·0187, its value at the last period. Consequently the rise of the sea would probably be somewhat greater than it was 11,700 years ago. Might not this be the period of the 40-feet beach? In this case 11,000 or 12,000 years would be the age of the 25-feet beach, and 60,000 years the age of the 40-feet beach.

About 22,000 years ago the winter solstice was in the perihelion, and as the excentricity was then somewhat greater than it is at present, the winters would be a little warmer and the climate more equable than it is at the present day. This perhaps might be the period of the submarine forests and lower peat-beds which underlie the Carse clays, Scrobicularia mud, and other deposits belonging to the age of the 25-feet beach. At any rate it is perfectly certain that a condition of climate at this period prevailed exceedingly favourable to the growth of peat. It follows also that at this time, owing to a greater accumulation of ice on the southern hemisphere the sea-level would be a few feet lower than at present, and that forests and peat may have then grown on places which are now under the sea-level.

For a few thousand years before and after 11,700 years ago, when the winter solstice was evidently not far from the aphelion, and the sea standing considerably above its present level, would probably, as we have already stated, be the time when the Carse clays, the stratified sand and mud which form our Glasgow Green, and other recent deposits lying above the present level of the river were formed. And it is also a singular fact that the condition of things at this period must have been exceedingly favourable to the formation of such estuarine deposits; for at this time the winter

* In order to determine the position of the solstice-point in relation to the aphelion, it will not do to assume, as is commonly done, that the point makes a revolution from aphelion to aphelion in any regular given period, such as 21,000 years; for it is perfectly evident that owing to the great irregularity in the motion of the aphelion, no two revolutions will probably be performed in the same length of period. For example, the winter solstice was in the aphelion about the following dates: 11,700, 33,300, and 61,300 years ago. Here are two consecutive revolutions, the one performed in 21,600 years and the other in 28,000 years; the difference in the length of the two periods amounting to no fewer than 6400 years.

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temperature of our island, as has been already shown, would be a few degrees below the freezing-point, and, consequently, during that season, snow would fall instead of rain. The melting of the winter's accumulation of snow on the approach of summer would necessarily produce great floods, similar to what occur in the northern parts of Asia and America at the present day from this very same cause. The loose upper soil would be carried down by those floods and deposited in the estuaries of our rivers.

The foregoing is a rough and imperfect sketch of the history of the climate and the physical conditions of our globe for the past 60,000 years, in so far as physical and cosmical considerations seem to afford us information on the subject, and its striking agreement with that derived from geological sources, is an additional evidence in favour of the opinion that geological and cosmical phenomena are physically related by a bond of causation.

We have assumed 1° 22′ 34″ greater than the present obliquity as the maximum. But this limit assigned by Laplace does not hold true for all time past.* And Sir John Herschel thinks that when millions of years are taken into account, the obliquity may even amount to 3° or 4° on each side of a mean state.†

Suppose, then, that at some past geological epoch the increase of the obliquity reached 4°, the equator would then be receiving 5·64 thermal days less heat than at present, and the poles upwards of 24 thermal days more heat than at present. The total quantity of heat received by the poles would therefore be nearly one-sixth more than at the present day. For every 6 pounds of ice now melted at the pole 7 pounds would then be melted. Were this condition of things to occur when the excentricity was near its superior limit, the hemisphere which had its winter occurring in perihelion at the time, would in all probability be completely deprived of its ice-cap, and forest-trees might then grow at the pole.

Were the obliquity increased by 4°, each square foot of surface at the poles would receive annually 51,802,000 foot-pounds more heat than at present, assuming that all the extra heat reached the ground. But suppose one-half of the rays to be absorbed in passing through the atmosphere, 25,901,000 foot-pounds per square

* *Mécanique Céleste*, Vol. ii., p. 857, note, Bowditch's translation.

† Lyell's "Principles," new edition, Vol. i., p. 282.

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foot would therefore represent the extra heat received by the poles. This would be sufficient to melt 4·12 cubic feet of ice. The additional heat resulting from the increase of 4° in the obliquity of the ecliptic would consequently melt a sheet of ice one mile in thickness in about 1300 years. A mile of ice removed from off the antarctic continent—and this is not an extravagant quantity, as we hope to be able to show on a future occasion—would raise the general level of the sea 206 feet. And to this must be added the rise resulting from the displacement of the earth's centre of gravity, which in the latitude of Scotland would amount to about 74 feet. This would give 280 feet as the total rise resulting from the melting of one mile of ice from off the face of the continent. It is quite conceivable that an enormous amount of ice might be melted on the southern hemisphere, while the quantity on the northern hemisphere remained undiminished. For if this extreme condition of obliquity were to occur at the time that the excentricity was at a higher value (a very likely event), and the winter solstice in the aphelion, the effects of excentricity would neutralize those of obliquity on the northern hemisphere, and consequently the quantity of ice on this hemisphere might not be diminished. But on the southern hemisphere the obliquity and the excentricity would conspire to produce the same effect, viz., a melting of the ice, and hence the effects that we have been considering, which would result from the removal of the ice, would necessarily take place to a greater or lesser extent.

The enormous effect that an extreme condition of excentricity must have in raising the temperature of the polar regions of the hemisphere which has its winter occurring in perihelion at the time, has been shown on a former occasion.* When such a state of things happens at the time when the obliquity is also at its superior limit, the combined effect of both causes would in all probability completely remove the polar ice-cap, and a submergence of the land on the opposite hemisphere to the extent of hundreds of feet would be the inevitable result.

It has been a matter of surprise how forest trees could have flourished near the poles, seeing that they must have been deprived of the sun's rays for several months in the year. But it must be observed that it is not necessary that trees should *grow* during winter when deprived of the sun's rays. All that is required is

* Phil. Mag. for Feb., 1867.

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that they should not die during that season. But all botanists know perfectly well that a forest-tree would not perish simply in consequence of being deprived of the direct rays of the sun for a few months, provided that it enjoyed a sufficient amount of heat. We are, however, not even warranted to conclude that the absence of the sun would prevent growth. It would affect the colour of the leaves, but it is doubtful whether it would seriously affect the growth of the tree. From a paper read before the French Academy, April 9, 1866, by M. P. Duchartre, it would appear that some plants grow much faster during night, when deprived of the sun's rays, than during daylight.

LVIII. *On the* CHEMISTRY *of some* CARBONIFEROUS *and* OLD RED SANDSTONES. By Mr. J. WALLACE YOUNG.

(Read March 28, 1867.)

SANDSTONE is generally understood to consist of quartz grains—popularly called sand—bound or cemented together into a more or less compact mass, the cementing material consisting of such substances as the carbonates of iron, lime or magnesia, clay, and silica. It is not my intention at present to enter into the origin of sand, but rather to draw attention to the nature of the cementing and colouring materials of some sandstones of the Carboniferous and Old Red formations, and more particularly those found in the neighbourhood of Glasgow.

On the Nature of the Cementing Material.—Sandstone may have been cemented together by the decomposition or re-arrangement of some of the constituents previously in the sand, or by the addition of such substances as carbonate of lime, and oxide of iron, deposited from springs. Professor Church, in some interesting notes on the recent formation of some rocks, observes, "that at Bude Haven, Cornwall, and elsewhere, coarse grained sand is in many cases being cemented together by the action of the water of land springs containing carbonic acid, which, percolating through the sand and dissolving the fragments of shells contained therein, the carbonate of lime is subsequently at some other point slowly deposited as the carbonic acid escapes, thus forming a cementing material for the sand."

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In cases where the quantity of carbonate of lime is large, it may probably have been derived from adjacent limestone rocks.

When we place a few fragments of a sandstone in hydrochloric acid and apply heat, we are enabled at once to determine whether the cementing material is acted on to any considerable extent. If of a siliceous or felspathic nature, it will be scarcely, if at all, affected; if, on the other hand, it consists of such substances as carbonate of lime, or peroxide of iron, it will be removed by the action of the acid, and the sandstone will be more or less disintegrated. After treating the sandstone with acid, it is necessary to make a careful examination of the residual sand. In the analyses which accompany this paper, I have, in general, indicated the nature of this sand in the different specimens examined. In most cases it appeared to consist of quartz grains, sometimes smooth and round, at other times small and angular, usually accompanied by a finely divided substance, which, in fact, possessed all the properties and composition of clay. I have frequently found as much as 7 or 8 per cent. of this clayey matter. Fragments of mica were almost invariably present, and always of the white variety; I have only twice observed any of the black variety, and this seems a little curious when we consider that it occurs so very frequently in those rocks from which the sand must have been derived. It has been suggested that as black mica seems to be more susceptible of change, it may either have been decomposed, or converted into the white variety.

Occasionally rounded fragments of felspathic or other analogous rocks were found accompanying the quartz. When we find quartz alone present, it is probable that the rocks from which those sandstones were derived, have undergone greater decomposition than those in which felspathic or other fragments are found. The former may have been solidified, decomposed, and re-solidified several times, until the only substances which point to the former presence of other matter, are the fine clay and fragments of mica. In the latter, on the contrary, we find some of the other rock fragments still entire, proving that they have not undergone the same extensive decomposition. I am here taking it for granted that the sand has been primarily derived from those crystalline rocks containing free silica.*

* M. Daubrée, by subjecting fragments of granite, &c., to rotation in a cylinder in presence of water, found, after a certain time, that the quartz was reduced to the

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It is often rather a difficult matter to indicate the conditions under which certain sandstones have been formed. Take, for instance, the hard fine white sandstone which is so extensively quarried at Bishopbriggs. According to the analysis given elsewhere, it consists of very fine rounded grains of quartz, a little mica, and some fine white clay, the whole cemented together by 33·49 per cent. of carbonates. Amongst these we find carbonate of iron to the extent of 6·62 per cent.; now, it is perfectly certain that atmospheric air (or oxygen) cannot have been present during its deposition, or else the iron would have been peroxidised and the carbonic acid separated. The same remark applies to all those cases in which carbonate of iron is present. Generally speaking, I find that those sandstones which contain carbonates are harder the greater the quantity present. This agrees with the observations of Bischof.

I shall now proceed to give a short account of a few of the sandstones examined.

CARBONIFEROUS SANDSTONES.

Braidbar Quarry, Cathcart.—Some parts of this sandstone are curiously streaked in all directions with peroxide of iron, presenting often a most beautiful appearance. It is moderately fine grained, and not very hard. No effervescence with HCl.* The peroxide of iron was determined in one portion, and amounted to 1·52 per cent. The residue consisted of rounded quartz grains, a few plates of mica, and a considerable quantity of fine clay; this last seemingly acted the part of cementing material, At a part of the same quarry wrought underground, there is a marked difference in the nature of the cementing material; it consists of 13·24 per cent. of carbonates, as follows:—

Carbonate of Lime, . . .	5·27 per cent.
,, of Magnesia, .	3·04 ,,
,, of Iron, ...	4·93 ,,

residue, quartz grains, a little mica, and clayey matter.

Varieties from Newton Coal Pits, near Cambuslang.—(*a.*) The

state of fine sand, and the felspar to a very fine mud, the water at the same time becoming highly charged with alkaline silicate. It would thus appear that by the simple rubbing together of grain against grain, the felspar being reduced to a minute state of division, is decomposed by the water, alkaline silicates being removed in solution, and the silicates of alumina left as clayey matter. This appears to explain satisfactorily the reason we find felspar grains so seldom present, but almost always clayey matter accompanying the quartz.

* I have used the symbol HCl. for hydrochloric acid for the sake of brevity.

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curious brown bituminous sandstone, with the regular white streaks running through it, which has been described in the Transactions,* is found here. It possesses a faint odour like paraffin oil, and benzol dissolves out most of the bitumen. It effervesces slightly with HCl. Residue, quartz grains, a little mica, and a considerable quantity of fine white clay.

The white streaks are in some pieces remarkably straight, and occur at regular distances; in other pieces, however, they become gradually closer and more confused, running into one another, become abrupt, and then cease, the sandstone being then of a uniform brown colour throughout. Large portions, evidently of the same sandstone, are white, with a single brown bituminous streak here and there. I cannot agree with the explanation of these phenomena given in the paper previously referred to. The bitumen appears to me to proceed rather from the simple decomposition of vegetable matter under certain peculiar circumstances, but I am quite unable to account satisfactorily for the remarkable regularity of the white lines.

(b.) A beautiful micaceous sandstone; splits readily into very thin layers, the surfaces of which are very thickly covered with plates of mica and purple-coloured spots of peroxide of iron. Effervesced with HCl., the acid removed some carbonate of lime, a little alumina, a large quantity of peroxide of iron, and slight traces of magnesia. Residue, white, contains quartz, mica, and fragments of some felsphatic or other analogous rock, and a little clayey matter. Solution of carbonate of sodium extracted a very little silicic acid from the residue.

No. 1. This variety is white and friable; effervesced slightly with HCl., which extracted 3·44 per cent of substance, the composition of which is shown in No. 1 of the following table :—

	1	2	3	4	5
Carbonate of Lime, ...	2·06	20·06	14·60	13·87	17·97
,, Magnesia,	traces	14·78	11·21	6·51	14·59
,, Iron, ...	1·38	———	5·51	6·07	·97
Peroxide of Iron, ...	traces	4·4	———	———	2·25

No. 2 is the soluble portion of some large red lumps found in the foregoing sandstone; they are very hard, and easily separated

* XIV. (p. 35.) On some peculiar varieties of Old Red and Carboniferous Sandstones from the neighbourhood of Glasgow. By John Young.

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from the white. Residue, colourless quartz grains, and a little clayey matter.

No. 3. Another variety; greyish-coloured, and rather hard. Residue, quartz grains, pretty large, and transparent.

No. 4. Colour, white; fine-grained; hard. Residue, quartz grains, with a small quantity of clay.

No. 5. Colour, brownish-red, speckled with white; hard. Residue, quartz sand with a little mica.

These varieties are principally interesting on account of the large and varying quantities of the carbonates of lime and magnesia, which accompany the carbonate of lime. It may perhaps be necessary to state here, that the foregoing table, and other subsequent ones, display the composition of the substance removed from each sandstone by HCl., the residual sand forming the remainder of the 100 parts.

Varieties from Bishopbriggs Quarries.

	1	2	3	4
Carbonate of Lime,.....	5.0	17·32	6·87	10·92
,, Magnesia,..	2·66	9·55	3·75	traces
,, Iron,.....	2·38	6·62	2·79	·93
Peroxide of Iron,.....	·76	·88	·67	·48

Nos. 1 and 3. From quarry near railway station. Colour, whitish; fine-grained; moderately hard. Residue, quartz grains with fragments of mica, and some fine white clay.

No. 2. From adjoining quarry; a very hard variety; colour, white; fine-grained. Residue, very fine rounded grains of quartz, with a few plates of mica, and a considerable proportion of fine white clay.

No. 4. From the side of a trap-dyke.

Nos. 1, 2, and 3, are extensively used as a building material.

From a Coal Pit near Bishopbriggs.—This sandstone contains layers of a brown impure iron ore running through it; contains 16·07 per cent. of protoxide of iron = 25·89 per cent. of carbonate, also some carbonate of lime and magnesia, peroxide of iron, and a trace of alumina, which were not estimated. Residue, quartz grains, with fragments of mica. It would appear that a deposition of iron ore was occurring simultaneously with the formation of this sandstone. Another specimen of a very similar nature and appearance, from near Edinburgh, contained 12·30 per cent. of protoxide of iron = 19·81 per cent. of carbonate.

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Eastfield, near Cambuslang.—The portion examined was not very hard. Colour, greyish, owing to the presence of a little carbonaceous matter; effervesced with HCl., which removed 7·53 per cent. of substance, as follows :—

Carbonate of Lime,	. . . . .	4·80 per cent.
,, of Magnesia,	. . . . .	1·93 ,,
,, of Iron,	. . . . .	·80 ,,

Traces of manganese and peroxide of iron. A large round mass found in this sandstone, and which it appears the quarrymen call "bastard whin," was simply a very hard cream-coloured piece of sandstone. Effervesced with HCl., which dissolved 29·26 per cent. of carbonates, as follows :—

Carbonate of Lime,	. . . . .	15·42 per cent.
,, of Magnesia,	. . . . .	9·84 ,,
,, of Iron,	. . . . .	4·00 ,,

The difference in hardness is owing to the increased amount of carbonates. These large round masses are very frequently found in quarries. The sand of which they are composed appears to be similar to that of the surrounding rock, the only difference, as far as I could see, being in the amount of cementing material.

Abbey Craig, near Stirling.—Colour white; coarse grained, and not very hard. HCl. extracted 4·33 per cent. of substance—

Carbonate of Lime,	. . . . .	2·00 per cent.
,, of Magnesia,	. . . . .	·48 ,,
,, of Iron,	. . . . .	1·85 ,,

The residue contained a considerable quantity of fine white clay.

The Wallace Monument is, I understand, partly built of this stone. As it is in many parts so extremely coarse grained, and owing to the nature of the cementing material, I cannot believe that it will possess the durability requisite for a memorial of this kind.

Craigleith, near Edinburgh.—Fine grained, hard; colour white. Gives a very slight, but decided effervescence with HCl. The acid solution contained small quantities of peroxide of iron and lime. Residue, quartz grains, with a little mica. The cementing material appears to be felspathic matter. In other sandstone from Mugdock, Locherdinan, near Strathblane, Carluke, &c., the cementing matter was also of a similar nature.

The copper ore, which was formerly wrought at Gourock, occurs disseminated in a conglomerate sandstone. The peebles are princi-

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pally quartz, and the cement appears to be of clayey or felspathic nature.

Slamannan.—Colour, greyish-white, very hard; contains the remains of shells *(Anthracosia)*. HCl. removes 60·20 per cent.

Carbonate of Lime, ...	51·06 per cent.
,, of Magnesia, ...	3·78 ,,
,, of Iron, ...	4·39 ,,
Peroxide of Iron and Alumina, . . .	·97 ,,

Residue, fine quartz sand, with some clayey matter, and plates of mica.

The red sandstone which overlies the Carboniferous strata in the West of Scotland effervesces freely with HCl. The acid solution contains large quantities of lime and peroxide of iron, and a little magnesia. Residue, not quite colourless, and not wholly quartz sand; a considerable quantity of white mica is present, and a few fragments of the black variety.

Giffnock Quarry, near Pollokshaws—Colour, whitish; fine grained; moderately hard. HCl. removed 10·02 per cent. of substance—

Carbonate of Lime, ...	4·78 per cent.
,, of Magnesia, ...	2·49 ,,
,, of Iron, ...	2·36 ,,
Peroxide of Iron, -	·39 ,,

Residue, very fine quartz sand, with some mica, and a little clayey matter.

A rounded mass of the so-called "bastard whin," nearly seven feet in circumference, was found lying in this quarry. It was extremely hard, and it was with difficulty that fragments sufficient for analysis could be obtained.

Colour, white; fine grained. HCl. removed 39·80 per cent. of carbonates—

Carbonate of Lime, ...	19·53 per cent.
,, of Magnesia, ...	10·62 ,,
,, of Iron, ...	9·65 ,,

Residue, similar to the foregoing.

A part of the surface of this lump was very much decomposed, being of a deep brown colour and quite soft, from the decomposition of the carbonate of iron.

Old Red Sandstones.

Falls of Clyde, Lanark.—Colour, purplish red; coarse grained; effervesced briskly with HCl. The acid solution contained a large

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quantity of peroxide of iron and lime, some protoxide of iron and alumina, and a trace of magnesia. Residue, fragments of different coloured quartz, felspar, a little mica, and a few dark-greenish grains.

From the Tweed at Dryburgh.—Colour, deep red; fine grained; considerable effervescence with HCl. The solution contained a large quantity of lime and peroxide of iron, with considerable traces of magnesia and protoxide of iron. Residue, not quite colourless, and not wholly quartz, small quantities of clay and mica being present.

Finnich Glen.—Colour, reddish; brisk effervescence with HCl. Some portions of this sandstone are much harder than others; the following table shows the composition of the part removed by the acid from the two varieties:—

	Harder Portion.	Softer Portion.
Peroxide of Iron, .	2·10 per cent.	1·27 per cent.
Carbonate of Lime,	16·60 ,,	10·95 ,,

Residue, not quite colourless, principally quartz, with a little felspar. No mica observed in portion examined.

Port-Glasgow.—Colour, greyish white; rather hard. HCl. removes 16·40 per cent. of substance—

Peroxide of Iron and Alumina, . . .	·30 per cent.
Carbonate of Lime, ...	16·10 ,,

Considerable tracts of magnesia. Residue, chiefly quartz, not quite colourless, a little mica and fine clay. This sandstone occurs in regular beds, alternating with a reddish marl or limestone.

Loch Thom, above Greenock, Ballagan Series.—Colour, dirty white; moderately coarse grained and hard. The cementing material is in this case carbonate of lime, with considerable traces of protoxide of iron and magnesia.

From Arbroath.—Colour, pale reddish; coarse grained. HCl. removed 23·18 per cent. of substance—

Peroxide of Iron and Alumina, . . .	5·22 per cent.
Carbonate of Lime, ...	17·06 ,,

Traces of protoxide of iron and magnesia. Residue, not quite colourless, fragments of quartz and felspar. A considerable quantity of white mica was present, accompanied with a few fragments of the *black* variety.

Many other varieties of sandstone from Largs, Dumbartonshire,

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and other districts, invariably contained carbonate of lime in conjunction with a ferruginous clayey matter.

Conglomerate, Callander, Perthshire.—Hard; appearance, red. Consists of various pebbles such as porphyry, quartz, greenstone, mica slate; a slight effervescence was perceived with HCl. The cementing material is of a felspathic nature, produced evidently by the decomposition of some of the ingredients.

Two varieties of red sandstone (Permian?) from Annan, Dumfriesshire, contained no carbonates, the cementing material being a ferruginous clay.

From Gourock.—Colour, whitish; rather hard. HCl. removed 26·87 per cent. of substance—

Alumina and Peroxide of Iron, . . .	·32 per cent.
Carbonate of Lime, ...	26·55 ,,

Residue, quartz sand, with some felspar and a few particles of mica.

From Bute.—Colour, red. Effervesced with HCl., which removed the following:—

Peroxide of Iron, ...	2·07 per cent.
Carbonate of Lime, ...	6·07 ,,

Traces of magnesia and alumina. Residue, colourless, chiefly quartz grains, with some fine white clay.

From Dumbartonshire.—Coarse grained; colour, red; contained mica. HCl. removed the following:—

Peroxide of Iron, ...	2·70 per cent.
Carbonate of Lime, ...	9·60 ,,

From Lossie Mill, Forfarshire.—Colour, greyish; fine grained. Effervesced with HCl. The solution contained considerable quantities of protoxide of iron and lime, with some alumina and peroxide of iron. The residue consisted of insoluble silicates, quartz, and fragments of mica. A boiling solution of carbonate of sodium extracted a considerable amount of soluble silicic acid from the residue.

Caithness Flagstone.—Used as a paving material; colour, greyish; irregular bands of quartzoze matter running throughout. Effervesced with HCl. The acid solution contained lime, magnesia, alumina, and protoxide of iron. The residue consisted of insoluble silicates, quartz, and fragments of mica. Solution of carbonate of sodium extracted a considerable portion of soluble silicic acid.

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The two foregoing sandstones differ entirely from all those previously examined; they appear to consist of—

Carbonates.	Insoluble Silicates.
Soluble Silicates.	Quartz, and fragments of Mica.

In general appearance and character they approach rather to a clayslate than to sandstone.

On the Colouring Matter of Sandstones.

Iron, in one shape or another, from its wide diffusion, is unquestionably one of the most common colouring matters of sandstone. It produces the various shades of brown, red, purplish red, crimson red, &c., so frequently observed. These shades of colour appear to be due to peroxide of iron alone, and their difference of tint may, perhaps, be owing partly to varied degrees of hydration, according to the circumstances under which they were produced. It is well known that artificially prepared peroxide of iron differs much in shade, according to the source whence it was obtained

The red colour of sandstones seems not to depend so much on the *amount* of peroxide of iron present as upon the way in which it occurs. Upon examination, each little quartz grain of which the sandstone is composed, will be found to have a slight coating of the red oxide, and which in most cases can be readily removed by HCl. A small portion of peroxide of iron thus appears to be able to colour a considerable quantity of sand.

A sandstone which may appear almost quite white to the eye often contains more peroxide of iron than a red one; but upon further examination, it will generally be found that it proceeds from minute specks or spots, disseminated throughout the mass. This, of course, applies exclusively to *peroxide of iron*, as large quantities of *protoxide* of iron may exist without colouring the sandstone.

In many red sandstones we find white blotches and spots, round rings, &c. These appear to be due to the removal of some of the iron oxide. The following analyses may serve to illustrate this:—

	1		2		3	
	A Per Cent.	B Per Cent.	A Per Cent.	B Per Cent.	A Per Cent.	B Per Cent.
Peroxide of Iron, . .	·14	·76	·65	2·20	·37	1·75
Carbonate of Lime, .	...	...	13·30	12·72	2·22	1·15
Carbonate of Magnesia, Sand, &c., . .	...	...	trace.	trace.	...	...

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No. 1. *From Port-Glasgow.*—Colour, deep red, with large irregular white blotches; not very hard. No effervescence with HCl. Residue, quartz grains with a little mica. Peroxide of iron in "A" the white, and "B" the red portion.

No. 2. *From Dumbartonshire.*—Colour red, with large white blotches; moderately hard.

"A." Substance removed from the white part by HCl.
"B." ,, ,, red ,,

No. 3. *From Largs.*—Fine grained; moderately hard.

"A." Substance removed from the white part by HCl.
"B." ,, ,, red ,,

Residue, quartz, with some felspar, and a few fragments of mica.

The only explanation which has been given of these phenomena, as far as I am aware, is the presence of some organism in the sand, the decomposition of which has reduced the peroxide to the protoxide of iron, which would be subsequently removed as carbonate, by water containing carbonic acid percolating the mass.* The carbonate of lime would be, of course, added subsequently.

Silicates of iron frequently colour sandstones green, but I have not met with any of these. The only green coloured sandstone which has come under my notice, is a fragment I picked up on the seashore at Portobello, near Edinburgh, the colour being due to a carbonate of copper. The following is the centesimal composition:—

Alumina and Peroxide of Iron, . .	·30	
Carbonate of Lime, ...	6·50	
Carbonate of Copper, ...	3·40	(Cu O. 2·5 per cent.)
Loss on drying at 100° C., . . .	1·35	
Quartz Sand, &c., ...	88·15	
	99·70	

Sandstones of different shades of brown and black are often found in our coal measures; the former generally proceeding from bituminous, and the latter from carbonaceous, matter.

The peculiar striped variety of sandstone referred to at page 201 must be classed with these, but the exact method by which the alternate layers were produced must still be matter of conjecture.

* Mr. James Bennie, who has so diligently investigated the surface geology of Glasgow, informs me that he has frequently observed sand in contact with decaying roots or twigs to be partially bleached.

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The principal results of my experiments lead to the following conclusions:—

1st. That in the greater number of sandstones examined, the cementing material consisted of carbonates.

2nd. That very considerable quantities of the carbonates of iron and magnesia frequently accompanied the carbonate of lime, although no definite ratio seems to exist between them. That the carbonates were chemically combined in some way is, the Author thinks, probable, as weak acids caused only a very feeble effervescence in those sandstones where any considerable quantity of the carbonates of iron and magnesia was present, differing entirely from the very brisk action of a similarily diluted acid where carbonate of lime alone existed.

3rd. That these sandstones generally speaking were harder the greater the proportion of carbonates.

4th. Mica was found to be present in nearly all those examined, and, with two exceptions, was always of the white variety.

5th. Soluble silicates were only found in three sandstones in any quantity; all three belonged to the Devonian system.

6th. Insoluble silicates which, for want of a better name, I have in general called felspathic or clayey matter, appear to be almost always present in more or less quantity.

7th. The round masses so frequently encountered in quarries in our neighbourhood, and known as "Bastard whin," by whatever cause produced, appear to be simply parts in the sandstone rock, which have become excessively hard from an increased proportion of carbonates, and are thus more or less easily separated from the surrounding rock.

8th. That the different red shades of colour observed in sandstones, more particularly in those belonging to the Devonian group, appeared to be due solely to peroxide of iron, and that the white rings and spots so frequently met with, have resulted from the reduction and subsequent removal of the greater part of this iron.

LIX. *On the* BALLAGAN *Series of Rocks.* By Mr. J. WALLACE YOUNG.

(Read February, 1867.)

IN a former paper read before the Society,* I pointed out the

* Art. XXXIV., p. 64, "On the presence of Magnesia in Rocks."

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general composition of some rocks known as the "Ballagan Limestones;" since then, however, I have made a more minute investigation of the rocks of the series, more particularly as they are developed in Ballagan Glen.

In the fine section there exposed, there are, I understand, upwards of 230 alternating beds of dolomitic limestones, sandstones, and shales. The limestones vary in thickness from 1½ inches to about one foot. They partake somewhat of a nodular character, and are quite amorphous in structure; the colour is usually grey, but some layers have a more or less red tinge. Some of these are very hard, others again break easily into splintery fragments.

The shale beds parting the limestones are sometimes not over 1½ inches thick, but more frequently from one to two feet; they vary from a sandy shale to a fine clay shale, and all more or less effervesce with hydrochloric acid. The following analysis may serve to give some idea of their composition:—

Dried @ 100° C.

Sand and Clay,	77·61 per cent.
Soluble Silicic Acid,	2·73 ,,
Lime,	2·15 ,,
Magnesia,	1·59 ,,
Oxide of Iron and Alumina,	8·37 ,,
Carbonic Acid,	1·64 ,,
Water and Loss,	5·91 ,,
	100·00 ,,

The sandstones are impure, consisting of quartz grains cemented with felspathic matter; treated with hydrochloric acid, a mere trace of carbonic acid was given off. The sandstones and sandy shales contain abundance of small fragments of mica.

Horizontal layers of white fibrous gypsum are common, and a red granular variety is found generally at right angles to the other; this last being of more recent date than the white, which, from its position, must have been formed at, or shortly after, the deposition of the shale beds.

Eight specimens of the limestone were taken from different beds, proceeding from the lowest to the very highest of the series, in order to determine the relative quantities of lime and magnesia.

The following table gives the result of the analysis:—

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Dried @ 100° C.								
	1	2	3	4	5	6	7	8
Insoluble, .	18·12	22·40	18·40	21·60	13·59	20·50	20·55	23·25
Lime, . .	24·16	23·35	23·80	23·50	26·99	24·25	24·10	23·00
Magnesia, .	16·35	14·15	17·20	14·25	17·21	15·00	15·15	15·10

No. 1 was from the lowest exposed bed; colour, reddish. Nos. 2, 3, 4, 5, 6, 7, and 8, beds in ascending order; colour, grey. It must be understood that these specimens were taken from every eighth or tenth alternate layer of limestone, and represent the whole vertical height of the exposed strata. A full analysis was made of the specimen marked No. 5, in order to give some idea of the general proportion of the other ingredients.

No. 5.—Dried @ 100° C.

Clay and Sand, } Insoluble matter.		11·92 per cent.
Silicic Acid, }		1·67 ,,
Lime, ...		26·99 ,,
Magnesia, ...		17·21 ,,
Protoxide of Iron, ...		·64 ,,
Oxides of Iron and Alumina, ...		2·67 ,,
Carbonic Acid, ...		38·00 ,,
Loss, &c., ...		·90 ,,
		100·00 ,,

In this analysis it will be observed that the carbonic acid is less than is required for the formation of the normal carbonates of lime and magnesia; some part of either, or both, must therefore have been combined with the silicic acid. The insoluble matter when fused with alkaline carbonate, and tested in the usual manner, was found to consist of silicic acid and alumina (or clay), and only very small quantities of lime and magnesia. Notwithstanding the presence of so much gypsum in the series, I could not detect anything but the merest traces of sulphuric acid in any of the specimens examined. However, in Auchenreoch Glen, near Dumbarton, where this same formation occurs, the limestones were found to contain no inconsiderable quantity of sulphuric acid, and fissures are often found filled with radiating crystals of gypsum.

I had intended examining in a similar manner some of the dolomitic limestones, from the other localities where this formation

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is exposed, but I have been only able as yet partially to examine two varieties from the beds situated in the hills above Greenock. The strata are there inclined at a pretty high angle, but have a similar appearance to those in Ballagan Glen. I could not find here any gypsum, but there are abundant layers of white fibrous carbonate of lime, and which presents the same aspect, and occupies a similar position to the gypsum in Ballagan Glen.

The following table exhibits the proportions of insoluble, lime, and magnesia, in the two beds :—

	1	2
Insoluble,	8·35	5·7
Lime,	28·65	29·55
Magnesia,	18·25	19·25

These specimens are much purer than the others, and it would be interesting to find out what relative position they occupy with regard to the strata in Ballagan Glen, seeing they are so far apart.

I do not think that we can explain the formation of these beds upon the supposition that they were originally limestone, and subsequently converted into dolomite. From their somewhat nodular structure and impure character, it appears as if they had rather proceeded from the segregation of a dolomitic mud, so to speak. At all events it is quite evident that the conversion—if such was required—must have taken place at, and not subsequent to, their deposition. The presence of gypsum in the series does not support the idea that the magnesia may have originally existed as sulphate, the relative amount being so small.

LX. *On the* Analysis *of a* Green Fibrous Mineral *from* Cathkin. By Mr. J. Wallace Young.

(Read December 6, 1866.)

The mineral of which I now give the analysis seems to have been derived from the decomposition of alteration or hornblende. It is frequently found in the trappean districts around Glasgow, generally mixed up with more or less carbonate of lime.

Colour, blackish green; structure, fibrous; of about the hardness of talc. The powdered mineral feels greasy when rubbed between

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the fingers. Gives off water when heated. B.B. becomes first whitish, and then fuses on the edges to a black glass. Easily decomposed by hydrochloric acid. The following is its composition, No. 1. is the whole mineral, and No. 2. after deducting the carbonate of lime.

Dried @ 100° C.	1	2
Silicic Acid,	31·95	33·38
Alumina,	15·40	16·10
Ferrous Oxide,	21·10	22·04
Magnesia,	20·95	21·90
Water (by difference),	6·30	6·58
Carbonate of Lime,	4·30	
	100·00	100·00

LXI. *On the* Entomostraca *of the* Carboniferous Rocks *of* Scotland. By Professor T. Rupert Jones, F.G.S., and James W. Kirkby.

(Read April 18, 1867.)

It is now more than seventy years since the earliest known specimens of the class of fossils we are about to notice were in the hands of Scottish palæontologists—or at least in the hands of one whom the palæontologists of Western Scotland may with honour look upon as their forerunner in the science. In 1793, David Ure had collected, and to some extent figured and described, not less than eight species of Bivalve Entomostraca, chiefly from the Carboniferous rocks of the parishes of Rutherglen and East Kilbride.* The discovery of these species speaks largely for Ure's close observation; and in this respect he compares favourably with many who have followed him in the path of palæontological research.

After Ure, nothing was done in the further investigation of these fossils for many years. The figures in the "History of Rutherglen and East Kibride," and the mounted specimens given by him to his friends, John Hunter and Dr. Anderson, still

* The History of Rutherglen and East Kilbride, published with a view to promote the study of Antiquity and Natural History. By David Ure, M.A., Preacher of the Gospel. 11 Plates of Carboniferous Fossils. 8vo. Glasgow: 1793.

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remained, but apparently unnoticed; and it is somewhat remarkable that, with one exception *(Kirkbya Urei)*, none of Ure's species were placed in the list of Carboniferous fossils until they were rediscovered and described by other authors. Indeed, if we put aside Hibbert, who described two species from the Limestone of Burdiehouse, nothing more was done in Carboniferous Entomostraca in Scotland from the time of Ure until the subject was taken up by the members of this Society within the last few years.

In other parts of the United Kingdom, and on the Continent, Carboniferous species had been described, some of which have subsequently been found in Western Scotland. In 1830, Count Münster described eight species from the Mountain-limestone near Hof, in Bavaria.* In 1836, a species characteristic of the Coal-measures was described by Mr. W. Bean;† and in 1839 another was noticed by Messrs. Murchison & Sowerby‡ from the Coal-measures of Shropshire. In the same year Prof. M'Coy described a large and curious Entomostracan which he named *Entomoconchus Scouleri*.§ Three years later (1842) six species were described in Belgium by Prof. De Koninck, only one of which has yet been found in Scotland.‖ In 1844, M'Coy gave figures and descriptions of 23 additional species from Ireland,¶ but which apparently do not represent more than thirteen species—including three already described, several of which occur in Scotland. Lastly, in 1860, D'Eichwald figured and described eleven new species from Russia, two of which have been found by Mr. J. Young in Western Scotland.**

As we have been engaged for some years in collecting materials preparatory to describing the British Carboniferous Entomostraca, we have had many specimens sent us from various parts, both in Britain and abroad. A great quantity of our specimens have been collected in the West of Scotland by members of the Society. So largely, indeed, are we indebted to the very close researches of several of our Scottish friends, and more especially to those of Messrs. John Young, James Thomson, J. R. S. Hunter, James Armstrong, and

* Leonhard & Bron's "Jahrbuch fur Mineralogie," &c., 1830., pp. 60-70.
† Mag. Nat. Hist., vol. ix., p. 37.
‡ Silurian System, p. 84.
§ Journ. Geol. Soc., Dublin, vol. ii., p. 91., pl. 5.
‖ Descrip. Anim. Foss. Terr. Carb. Belgique, p. 585-590, pl. 52.
¶ Syn. Char. Carb. Foss. of Ireland, p. 164-168, pl. 23.
** Lethæa Rossica, vol. vii. (1860), p. 1336-1349, pl. 52.

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Dr. Rankin, that we deem it a duty as well as a pleasure to accede to the request that has been made to us to furnish the Society with a short account of the Entomostraca that have been found in the Carboniferous rocks of Scotland. Moreover, as a list of the Scottish species includes two-thirds of all those that have been found in Britain, it is almost a matter of importance that some account of them should be published in the "Transactions" of this Society.

We need scarcely observe that the Entomostraca form a subclass of the Crustacea. Those we have to notice belong to two groups, the Phyllopoda and the Ostracoda. Of the former, *Limnadia* is one of the nearest allies in the living state, and of the latter, the recent forms *Cypris* and *Cythere* may be taken as types. A few species are not included in this section. *Dithyrocaris*, for instance, belongs to a distinct and very different group. *Estheria*, not here treated of, is also one of the Phyllopoda. We may observe that we do not include in our lists the few Carboniferous species of *Trilobita* and *Eurypterida* which are now generally placed in the Entomostraca.

It will be seen from the lists that follow that fifty-eight species of Entomostraca have been found in the Carboniferous strata of Scotland. All of these, with one exception, occur in the lower beds of the series, and five of them extend up into the highest.

Of the above fifty-eight species about a fourth belong to *Cythere;* though *Cythere* among fossil Entomostraca is sometimes a genus of convenience, and may probably be made to include several forms which would be differently placed, were their true relations better understood. Most of the *Cytheres* in our lists have smooth-shelled carapaces and a simple style of outline. We might almost term them the puritans of the list in their severe simplicity of character, compared with their more ornate neighbours the *Beyrichiæ* and *Kirkbyæ*. They are very abundant as individuals in the ironstones and shales of the Upper-Coal-Series; but they are more plentiful as to species in the limestones and underlying strata.

Bairdia, which forms a group of species nearly allied to *Cythere*, though possessed of a carapace of quite different outline, is also a common form in the Glasgow district; but, unlike *Cythere*, it is only found in the Limestone Series. Its species appear to have been essentially marine in their habits and never to have ventured into regions where the water was brackish or fresh. *Bairdia curta*,

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M'Coy, including its variety *plebeia*, is the most characteristic form of the genus; and it is scarcely more abundant in Carboniferous rocks than in those of a Permian age.

Leperditia is another genus common in the Carboniferous rocks, beyond which, in an upward direction, it does not seem to extend. One species, *Lep. Okeni* (formerly *Cypris subrectus* and *C. Scoto-burdigalensis*) is usually the prevailing Entomostracan in the marine beds of Carluke, Craigenglen, Orchard, and other localities in the Upper and Lower Limestone Series. The species of this genus are all easily known by the obliquity of the valves and the elevated eye-spot at the antero-dorsal region of the valves. A species peculiar to the West of Scotland, *Lep. Armstrongiana*, has the latter character very strongly developed.

Beyrichia has also several species, and they all can be easily recognized by having the valves curiously pinched and divided into two or more lobes, by transverse or oblique sulci. Most of them are confined to the strata below the Upper Coal Series; though one is very common in the shales and ironstones of the higher part of the system.

Related to *Beyrichia* is the genus *Kirkbya*, which as yet is only known in Carboniferous and Permian strata. Eight species occur in the West of Scotland, but they are found only in the limestones and calcareous shales below the Upper Coals.

There are four species, larger than any of the preceding, which belong to the recent genus *Cypridina*. This is a well-marked type, and besides being of large size, it can always be distinguished by its characteristic anterior beak and notch. M'Coy noticed a species of it, referring it to *Daphnia*.

A single representative of the curious Entomostracan *Entomoconchus Scouleri* also occurs. This genus has been found only in Carboniferous rocks.

Another also occurs belonging to *Entomis*, a Palæozoic genus, as well as three species of *Dithyrocaris*.

Of *Estheria* there are three species, all of which have been previously described.*

The following Tables show the distribution of the species:—

* Monograph of the Fossil Estheriæ. By T. Rupert Jones. Published by the Palæontographical Scciety. 1863.

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LIST OF SPECIES FOUND IN THE UPPER COAL SERIES.

Species.	Horizons and Localities.	Mode of Occurrence.
1. *Beyrichia arcuata*, Bean.	Mussel-band Ironstone, Lanarkshire.	In dark grey ironstone. Numerous.
	Bellston Ironstone, Carluke.	In black, rather micaceous shale; with *Anthracomya* and scales of *Palæonisci*.
	Shotts Furnace Coal.	In dark grey shale; with *Anthracomya*. Numerous.
	Shotts Gas Coal.	In dark grey shale; with *Anthracomya*. Rare.
	Ayrshire Upper Coal Series.	In grey shale; with plant remains.
2. *Cythere fabulina*, Jones and Kirkby.	Palace Craig Ironstone, Lanarkshire.	In hard black ironstone. Numerous on planes of bedding.
	Airdrie Blackband, Lanarkshire	Abundant.
	Mussel Band Ironstone, Lanarkshire.	In hard grey ironstone. Very numerous.
	8 fathoms below Virtue Well Seam, Carluke.	In light-brown ironstone; with *Spirorbis carbonarius*. Very numerous.
	Mushet's Blackband, Whifflet, near Glasgow.	In hard brown ironstone.
	Provanhall.	In black carbonaceous shale; with remains of fish and plants.
	Airdrie, Lanarkshire.	In ironstone.
	Gilmerton, near Edinburgh.	Associated with *Lingula squamiformis*, and *Lepidodrendon* and other plants.
	And in several other localities.	
3. ——— *Rankiniana*, J. and K.	Blackband, Airdrie; Provanhall, Lanarkshire; Whifflet.	In highly carbonaceous shale; with plants and fish remains.
	8 fathoms below Virtue Well Coal, Carluke.	In light-brown ironstone; associated with *Spirorbis carbonarius*.
	Shotts Ironstone.	Numerous.
4. ——— *pungens*, J. and K.	Bellston Ironstone, Carluke; Provanhall.	In highly carbonaceous shale; with plants and fish remains. Numerous.
5. *Estheria tenella*, Jordan.	Shotts, Lanarkshire.	In black shale; with *Anthracosia* and *Spirorbis carbonarius*.

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LIST OF SPECIES FOUND IN THE STRATA BELOW THE UPPER COAL SERIES

	Species.	Horizons and Localities.	Mode of Occurrence.
1	*Dithyrocaris testudineus*, Scouler.	Lingula-limestone, Raes Gill, Carluke.	In limestone shales (upper series) with numerous marine Shells, etc
		Robroystone.	Do., do., do.
2	——— *Colei*, Portlock.	Craigenglen.	In lower limestone shales; with marine Shells, Corals, Crinoids etc.
3	——— *tenuistriatus*, M'Coy.	Lingula-shale, Robroy-stone.	In upper limestone shales; with marine Shells, &c.
		Lesmahagow.	Do., do., do.
4	*Entomoconchus Scouleri*, M'Coy.	West Broadstone, Ayr-shire; Main Lime-stone, Carluke.	In main limestone; with *Pro ducta* and *Spirifera*.
5	*Cypridina Grossartiana*, J. and K.	Lanarkshire.	
6	——— *Rankiniana*, J. and K.	Gare, Carluke.	In upper limestone shales; with marine Shells, Crinoids.
		Brockley.	In lower limestone shales; with do
		Braidwood Gill	Do. (Fish coprolite containing upwards of 300 specimens—un crushed.)
7	——— *Thomsoniana*, J. and K.	Gare, Carluke.	In a nodule of ironstone.
8	——— *primæva*, M'Coy.	Main Limestone, Car-luke.	Associated with *Producta*, *Pecten Cyathophyllum*, and other marine fossils.
9	*Cytherella inflata*, Münst.	Craigenglen, Campsie.	In lower limestone shales.
10	——— *simplex*, J. and K.	Lanarkshire.	In dark grey calcareous shale.
11	*Entomis concentrica*, De Koninck	Main Limestone, Car-luke.	Lower series; with numerous marine shells.
12	*Leperditia Youngiana*, J. and K.	Den, near Dalry.	In dark grey shale; with *Cythere* and Fish remains. Lower coal and blackbands in Possil iron stone series.
13	——— *Okeni*, Münster; with varieties.	Main Limestone, Car-luke.	With numerous marine fossils Rather common.
		Prod. punctatus beds, Carluke.	In coarse grey limestone; with *Crinoidea*, *Producta*, *Orthis*, &c Lower limestones.
		Gare, Carluke.	In upper limestone shales; with marine Shells.
		Craigenglen, Campsie.	In lower do.; with marine Shells

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	Species.	Horizons and Localities.	Mode of Occurrence.
13	*Leperditia Okeni*, Münster. *(Continued.)*	Campbeltown.	In sandy limestone; with *Spirifera*, *Producta*, *Euomphalus*, and other marine species.
		Brockley.	In calcareous shale; with do. do. Rare.
		Boghead Quarries, near Hamilton.	In upper limestone shales; with marine Shells, &c.
		Orchard near Thornliebank.	Do., do., do.
		West Broadstone, Ayrshire.	In lower limestone shales; with do.
		Armadale, near Bathgate	Dwarfed as var. *Scotoburdigalensis*. Common. Upper coal series on horizon of slaty band ironstone.
		Hurlet Pits, Renfrewshire.	Do.; in lower limestone grey shales, numerous.
		Bathgate.	In do.; in dark fissile shale with *Beyrichia multiloba*.
		And in numerous other localities.	
14	—— —— *compressa*, J. and K.	Craigenglen, Campsie.	In lower calcareous shale; with numerous marine fossils. Rather rare.
15	—— *oblonga*, J. and K.	Main Limestone, Carluke. Howrat Quarry, Dalry.	With *Producta*, *Cyathophyllum*, and other marine fossils; not rare. Lower limestone series.
16	—— —— *Armstrongiana*, J. and K.	Howrat, East Kilbride; Main Limest. Carluke; Brockley.	With numerous marine fossils. Lower limestone series.
17	*Beyrichia colliculus?* D'Eichwald.	Main Limestone, Carluke.	With marine fossils. Lower limestone series.
		Crossgatehall, near Edinburgh.	In ironstone nodules; with *Lingula squamiformis*, *Spirorbis carbonarius*, *Cythere fabulina*, *Rankiniana*, and *pungens*. Rare.
18	—— *subarcuata*, Jones.	Burdiehouse, Limestone.	In hard dark-grey limestone shale under the lower marine limestone series; with *Lep. Okeni* (numerous) and Fish remains. Rare.
19	—— *multiloba*, Jones.	Raes Gill beds, Carluke.	In alum shale; with small *Murchisonia*, &c. Lower limestone series.
		Boghead Quarries, near Hurlet.	In upper limestone shales; with numerous marine Shells, &c.
		Craigenglen, Campsie.	In lower do., very rare, with do.

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	Species.	Horizons and Localities.	Mode of Occurrence.			
19	*Beyrichia multiloba*, Jones. *(Continued.)*	? Campbeltown limestone.	In lower limestone shales.			
20	——— *fattigiata*, Jones.	Bathgate.	In grey shales above limestone Standhill near Bathgate.			
		Craigenglen, Campsie.	In calcareous shale; in lower limestone shales. Rare.			
		Crossgatehall, near Edinburgh.	In clay ironstone nodules, with *Lingula* &c. Numerous.			
21	——— *bituberculata*, M'Coy.	Orchard, near Thornliebank.	In upper limestone shales—marine Shells.			
		Main Limestone, Carluke.	With numerous marine fossils.			
		Brockley, near Lesmahagow.	In lower limestone shales—marine Shells, &c.			
		High Blantyre.	In upper do.; with do.			
22	——— *radiata*, J. and K.	Up. Limest., Orchard, near Thornliebank.	With numerous marine Shells, Crinoids, Corals, &c.; in soft friable shales.			
		——— Williamwood.	Do.,	do.,	do.	
		——— Robroystone.	Do.,	do.,	do.	Rare.
		——— Boghead Q.	Do.,	do.,	do.	
		——— Newfield.	Do.,	do.,	do.	Rare.
		——— Calderside.	Do.,	do.,	do.	Rare.
		Lo. Limest., Craigenglen	Do.,	do.,	do.	Rare.
23	——— *rigida*, J. and K.	Up. Limest., Orchard.	Do.,	do.,	do.	
24	*Kirkbya Permiana*, Jones.	Up. Limest., Robroystone.	Do.,	do.,	do.	Rare.
		——— Orchard.	Do.,	do.,	do.	
		——— Williamwood.	Do.,	do.,	do.	
		Lo. Limest., Brockley.	Do.,	do.,	do.	
25	——— *Urei*, Jones.	Up. Limest., Robroystone	Do.,	do.,	do.	Rare
		——— Boghead.	Do.,	do.,	do.	
		——— Newfield.	Do.,	do.,	do.	
		——— Calderside.	Do.,	do.,	do.	
		Lo. Limest., Brockley.	Do.,	do.,	do.	
		——— Craigenglen.	Do.,	do.,	do.	Rare
26	——— *spinosa*, J. and K.	Lo. Limest., Craigenglen.	Do.,	do.,	do.	
27	——— *Scotica*, J. and K.	Lo. Limest., Campbeltown.	Do.,	do.,	do.	Rare.
28	——— *annectens*, J. and K.	——— Brockley.	Do.,	do.,	do.	
		Up. Limest., Orchard.	Do.,	do.,	do.	

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Species.	Horizons and Localities.	Mode of Occurrence.			
28 *Kirkbya annectens*, J. & K. (*Continued.*)	Up. Limest., Williamwood.	With numerous marine shells, Crinoids, Corals, etc.; in soft friable shales.			
	—— Newfield.	Do,	do.,	do.	Rare.
	—— Calderside.	Do.,	do.,	do.	Rare.
	Lo. Limest., Brockley.	Do.,	do.,	do.	
	—— Craigenglen.	Do.,	do.,	do.	
29 —— *umbonata*, D'Eichwald.	Lo. Limest., Brockley.	Do.,	do.,	do.	
	—— Craigenglen.	Do.,	do.,	do.	Rare.
30 —— *oblonga*, J. and K.	Lo. Limest., Craigenglen.	Do.,	do.,	do.	
31 —— *Eichwaldiana*, J. and K.	Lo. Limest., Craigenglen	Do.,	do.,	do.	
32 —— *plicata*, J. and K.	—— Campbeltown.	Do.,	do.,	do.	
33 *Bairdia curta*, M'Coy.	Up. Limest., Orchard.	Do.,	do.,	do.	
	—— Williamwood.	Do.,	do.,	do.	
	—— Newfield.	Do.,	do.,	do.	
	—— Calderside.	Do.,	do.,	do.	
	—— Gare.	Do.,	do.,	do.	
	—— High Blantyre	Do.,	do.,	do.	
	Lo. Limestone, West Broadstone.	Do.,	do.,	do.	
	Lo. Limest., Carluke.	Do.,	do.,	do.	
	—— Howrat.	Do.,	do.,	do.	
	Lo. Limest., Brockley.	Do.,	do.,	do.	
	—— Craigenglen.	Do.,	do.,	do.	
34 —— *Hisingeri*, Münster.	Lo. Limest., Brockley.	Do.,	do.,	do.	
	—— Craigenglen.	Do.,	do.,	do.	
	—— Carluke.	Do.,	do.,	do.	
	—— Howrat.	Do.,	do.,	do.	
35 —— *brevis*, J. and K.	Lo. Limest., Carluke.	Do.,	do.,	do.	
	—— Brockley.	Do.,	do.,	do.	
	—— Craigenglen.	Do,	do.,	do.	
36 —— *subcylindrica*, Münster.	Up. Limest., Newfield.	Do.,	do.,	do.	
	—— Calderside.	Do.,	do.,	do.	
	—— High Blantyre	Do.,	do.,	do.	
	—— Williamwood.	Do.,	do.,	do.	
	—— Orchard.	Do.,	do.,	do	
	Lo. Limest., Brockley.	Do.,	do.,	do.	
	—— Craigenglen.	Do.,	do.,	do.	
	—— Carluke.	Do.,	do.,	do.	
	—— West Broadstone.	Do.,	do.,	do.	

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Species.	Horizons and Localities.	Mode of Occurrence.
37 *Bairdia mucronata*, Reuss; with var. *sub-mucronata*.	Up. Limest., Robroystone	With numerous Marine Shells, Crinoids, Corals, etc.; in soft friable shales. Rare.
	—— Orchard.	Do., do., do.
	—— Williamwood	Do., do., do.
	Lo. Limest., Carluke.	Do., do., do.
	—— Craigenglen.	Do., do., do.
	—— Brockley.	Do., do., do.
38 *Cythere fabulina*, J. and K.	Raes Gill Ironstone, Carluke.	In hard black clay ironstone; with *Lingula* and *Orthoceras*, and *C. Rankiniana*.
	White Limestone, Craigenglen.	In hard grey limestone without other fossils.
	Millburn, Campsie.	In dirty-yellow limestone; with scales of fish, *Spirorbis*, and remains of plants. Abundant.
	Possil.	From the stem of a *Lepidodendron* in blackband ironstone; dwarfed.
	356 fathoms below Ell Coal, Carluke.	In ironstone; forming the chief portion of the rock.
	Crossgatehall, near Edinburgh,	In ironstone nodules; with *C. Rankiniana* and *pungens*, *Lingula squamiformis*, & *Sp. carbonarius*.
	Lo. Limest., Robroystone.	In calcareous shale; with marine fossils.
39 —— *Rankiniana*, J. and K.	Raes Gill, Ironstone, Carluke.	In hard black clay band ironstone; with *C. fabulina*, *Lingula*, and *Orthoceras*.
	Crossgatehall, near Edinburgh.	In ironstone nodules.
40 —— *pungens*, J. and K.	Crossgatehall, near Edinburgh.	In ironstone nodules; with *C. fabulina* and *Rankiniana*, *Lingula squamiformis*, and *Spirorbis*.
	Lo. Limest., Craigenglen	In "freshwater limestone;" with *C. Rankiniana*, *fabulina*, *secans*, and *Spirorbis*.
41 —— *secans*, J. and K.	Lo. Limest., Craigenglen	In "freshwater limestone;" with do.
42 —— *subula*, J. and K.	Crossgatehall, near Edinburgh.	In ironstone nodules; with *C. Rankiniana*, *fabulina*, *pungens*, *Lingula*, and *Spirorbis*.
43 —— *Crosskeyana*, J. and K.	Bathgate.	In grey shale.
44 —— *obtusa*, J. and K.	Campbeltown.	In coarse sandy limestone; with *Producta*, *Spirifera*, and other marine fossils.

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	Species.	Horizons and Localities.	Mode of Occurrence.
5	*Cythere amputata*, Kirkby.	Lower Limestone, Carluke.	In the Main Limestone; with numerous marine fossils.
6	—— *bilobata*, Münster.	West Broadstone.	With *Producta*, *Spirifera*, &c.
		Lo. Limest., Carluke.	Do. do.
		Millburn, Campsie.	In "freshwater limestone;" with large variety of *C. fabulina* and *Spirorbis*.
7	—— *cuneola*, J. and K.	Up. Limest., Orchard.	With marine Shells, Crinoids, Corals, &c.; in soft friable shales.
		—— Newfield.	Do., do., do.
		—— Boghead.	Do., do., do.
		—— Robroystone.	Do., do., do.
		—— Calderside.	Do., do., do.
		Lo. Lime., Swindridge Moor, near Dalry.	Do., do., do.
		Lo. Limest., West Broadstone.	Do., do., do.
		Lo. Limest., Brockley.	Do., do., do.
8	—— *ventricornis*, J. and K.	Up. Limest., Orchard.	Do., do., do.
		—— Williamwood	Do., do., do.
		Lo. Limest., Brockley	Do., do., do.
		—— Craigenglen.	In calcareous shale; with marine fossils. Rare.
9	—— *cornigera*, J. and K.	Up. Limest., Orchard.	With numerous marine Shells; Crinoids, Corals, &c.; in soft friable shales.
		—— Williamwood.	Do., do., do.
		Lo. Limest., West Broadstone.	Do., do., do.
		Lo. Limest., Brockley.	Do., do., do.
		—— Craigenglen.	In calcareous shale; with marine fossils. Rare.
0	—— *intermedia*, Münster.	Lo. Limest., Carluke.	With many Marine fossils.
1	—— *Jonesiana?* Kirkby.	Lo. Limest., Craigenglen	In calcareous shale; with marine fossils. Rare.
2	*Cythere? Youngiana*, J. and K.	Lo. Limest., South Hill, Campsie.	In dark-blue shale; with *Orthoceras*, *Goniatites*, *Nautilus*, *Bellerophon*, *Pleurotomaria*, *Ctenodonta*, *Chonetes*, *Discina*, *Lingula*, &c.
3	*Bairdia grandis*, J. and K.	Lo. Limest., Carluke.	In the *Prod. punctatus* beds; with marine fossils.

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	Species.	Horizons and Localities.	Mode of Occurrence.
54	*Estheria striata*, Münster.	Lo. Coal, Lanarkshire.	In cannel coal.
		Lo. Coal, Berwickshire.	In black shale; with fish remains, *Spirorbis*, and plants.
55	——— *punctatella*, Jones.	Up. Limestone, Arden Quarry, Renfrewshire.	In dark aluminous shale; with *Modiolopsis*, *Pteronites*, *Producta*, and *Naidites*.
56	*Leaia Leidyi*, Lea.	Lower Carboniferous, Crail, Fifeshire.	In clay ironstone; with *Lepidodendron*.

We also give a vertical section of the Carboniferous Rocks near Glasgow (kindly prepared for us by Mr. John Young), to assist in explaining the range of the species in time. (See page 225.)

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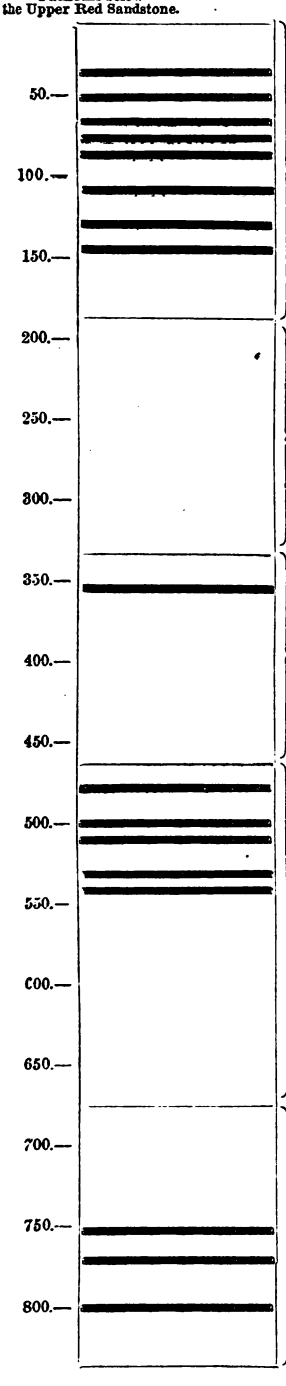
VERTICAL SECTION OF THE CARBONIFEROUS ROCKS IN THE NEIGHBOURHOOD OF GLASGOW.

Shewing the Distribution of the Bivalve Entomostraca.



Upper Coals and Blackband Ironstones.

Beyrichia arcuata, *Bean.*
Cythere fabulina, *J. & K.*
——— Rankiniana, *J. & K.*
——— pungens, *J. & K.*

Brackish, or Fresh Water Series, worked to the east of Glasgow.

Barren Ground:—Shales and Sandstones lying between the Upper Coals and the Upper Limestones.

Beyrichia bituberculata, *M'Coy.*
Kirkbya Urei, *Jones.*
——— Permiana, *Jones.*
——— bipartita, *J. & K.*
Leperditia Okeni, *Münster.*
Bairdia curta, *M'Coy.*
——— subcylindrica, *Münster.*
Cythere cuneola, *J. & K.*
——— cornigera, *J. & K.* &c., &c.

Upper Carboniferous Limestone Series, with many Marine Fossils, worked at Gare, near Carluke, Robroystone, Orchard, Williamwood, Newfield, Calderside, Boghead, near Hamilton, and High Blantyre.

Cythere fabulina, *J. & K.*
——— Rankiniana, *J. & K.*
Leperditia Youngiana, *J. & K.*

Lower Coals, and Blackband and Clayband Ironstones, worked at Possil, near Glasgow, Dalry, Ayrshire, Kilsyth, Carluke, and Lesmahagow.

Beyrichia multiloba, *Jones.*
——— fastigiata, *Jones.*
——— radiata, *J. & K.*
Kirkbya Urei, *Jones.*
——— bipartita, *J. & K.*
——— Permiana, *J. & K.*
——— umbonata, *D'Eichwald.*
——— Scotica, *J. & K.*
——— spinosa, *J. & K.*
Leperditia Okeni, *Münster.*
——— Armstrongiana, *J. & K.*
Bairdia curta, M'Coy.
——— Hisingeri, *Münster.*
——— brevis, *J. & K.*
Cythere cuneola, *J. & K.*
——— Youngiana, *J. & K.*
——— fabulina, *J. & K.*
——— Rankiniana, *J. & K.*
——— secans, *J. & K.*
——— pungens, *J. & K.*

Lower Carboniferous Limestone Series, with many Marine Fossils, worked at Campsie, Hurlet, Carluke, Braidwood, Brockley, Lesmahagow, and in various Quarries around Beith and Dalry, in Ayrshire.

Brackish or Fresh Water Limestones, alternating with Marine, Craigenglen, and Millburn, Campsie.

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An examination of the accompanying Tables shows that, with a few exceptions, all the species have been found in the Lower Limestone Series in the West of Scotland. Several of them do not extend beyond the limits of that subdivision, though the majority continue up into the Upper Limestone. Here most of them disappear, for only four are known to occur in the Upper Coals.

It is interesting to study this group of species in their life-history in the Carboniferous era. Their appearance and apparent dying out was not a regular, unbroken process. Nor do they all appear to have ever existed in one era at any one period of time, notwithstanding the presence of nearly all of them in the beds of one series. If we take, for instance, a limestone or calcareous shale with marine fossils, we generally find a group of Entomostraca composed of certain species of the genera *Cythere*, *Bairdia*, *Leperditia*, *Beyrichia*, and *Kirkbya*. Above these strata may come some arenaceous rocks or alum-shales, in which all the above species are absent. Perhaps the next stratum is one of what is termed "Freshwater Limestone," containing fish-remains, *Spirorbis*, and a few traces of vegetable fossils. Entomostraca appear again in this bed, and abundantly; but the species are different from those in the first-mentioned deposits. They are only three or four in number, and are all *Cytheres*. These disappear with the limestone. A few fathoms higher in the series another bed of shale comes in with many *Productæ* and other marine fossils, and with them all or most of the *Bairdiæ*, *Beyrichiæ*, &c., that had occurred before, with perhaps one or two forms to take the place of others that have not returned. The species all vanish again with the second bed of shale, and probably the next occurrence of Entomostraca will be considerably higher up, when one of the *Cytheres* of the "Freshwater Limestone" will return and abound alone in a single thin stratum. This interchange of species continues time after time; not, perhaps, always to the same extent, but always with some variation in the distribution. Nevertheless, there is considerable persistence in many of the species that return at different intervals; and it will be found that the same groups of species appear and reappear many times, without any essential change in their constitution. They always, moreover, reappear under exactly the same conditions. For example, if we take the following group of species:—

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Bairdia curta, *M'Coy.*	Kirkbya Urei, *Jones.*
Cythere cornigera, *Jones & Kirkby.*	Kirkbya bipartita, *Jones & Kirkby,*
Leperditia Okeni, *Münster.*	

we shall find that they occur in the Lower Limestone Series at Craigenglen and Brockley, and in the Upper Limestone Series at Orchard and Williamwood, in calcareous strata, associated with marine fossils; and also that they never occur under different circumstances, such as in ironstone with plants and fish-remains, or in calcareous shale with *Spirorbis carbonarius.* On the other hand, if we take the following trio as a group:—

Cythere fabulina, *Jones & Kirkby.*	Cythere pungens, *Jones & Kirkby,*
Cythere Rankiniana, *Jones & Kirkby.*	

they will be found in the lower strata of the system at Crossgate-hall, near Edinburgh, at Craigenglen, and in the upper strata at Whifflet, Shotts, Carluke, and Gilmerton, in ironstones and carbonaceous shales, with fish-remains, *Anthracosiæ, Spirorbis carbonarius,* and vegetable fossils, and never in limestone or other strata of indisputable marine origin.

Of course, from this, the question naturally resolves itself into one of the physical conditions that prevailed during the deposition of the different strata that go to form the Carboniferous Series of rocks in Scotland. This is a question foreign to the subject of our paper, besides being one which requires to be treated by one possessed of a thorough local knowledge of the subject. Still, we may observe that those Entomostraca which are only found in rocks containing Shells, Corals, and Crinoids, that can only have lived in seas that were salt, may be safely classed as being of marine origin; while those which are only found along with Plants, Fishes, Shells of uncertain habitat (excepting sometimes an occasional *Lingula*), and *Spirorbis,* are species that only existed in brackish water. It is, of course, the opinion of some that these latter species, as well as most of the animal remains found in the Coal-measures, were of freshwater origin. This, however, is an opinion that has not gained ground of late years; and it is one which the evident immense areas of the original unbroken coal-fields, the presence of tubicolar Annelids, the scarcity of terrestrial animal life, the occasional presence of true marine shells, (*Lingula, Aviculopecten, Goniatites,* &c.), and other circumstances all tend to disprove. Still, we imagine that those who hold that the shales,

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sandstones, ironstones, and coals which go to form what are termed Coal-measures, were of marine origin, do not mean more than that these rocks were deposited, and that the vegetation which formed the coals was grown, in the waters of large estuaries and lagoons, or along the shore-line of some continent. In this sense the marine origin of coal can be understood, and the scant nature of its fauna explained. The brackish water to be found under such circumstances will account for the small number of species and the large number of individuals usually met with fossil in nearly all coal-fields.*

LXII. ADDRESS *in* MEMORY *of* JAMES SMITH, ESQ., *of Jordan Hill*, F.G.S., *late President of the Society, delivered by* REV. HENRY W. CROSSKEY, *on the Evening of February 7th*, 1867.

I HAVE been requested by the Council to address you this evening, in order to express our deep sense of the loss this Society has sustained by the death of our lamented President, and our high regard for the services he has rendered to the cause of scientific research.

Mr. Smith, who was born in the year 1782, and died on the 17th January, 1867, was President of the Archæological Society as well as of our own Society; a fellow of the Royal Society, and a member of the Geological Societies of France and London. He was educated in the University of Glasgow. His taste for natural history was developed in connection with his love of yachting, and for many years he was the most adventurous, if not the only yachtsman, in the West of Scotland. In 1866, in company with Professor Milne and Dr. Ure, he made a voyage to the Isle of Skye in a small vessel of about 12 tons burden.

Serving as an officer in the Renfrewshire Militia, he was on duty at the Tower of London during the imprisonment of Sir Francis Burdett, and after the peace visited France and Italy.

Among the Institutions of Glasgow, he regarded the Andersonian University with especial interest, and from the year 1830 until his death, continued to take an active part in its management. He was elected to its presidency and enriched the Institution with many liberal gifts. He was the founder of its Natural History

* Unavoidable circumstances have hindered us from giving the concise account of the species that we had intended to draw up.—T. R. J. and J. W. K.

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Museum, and deposited in its charge large collections both of British and fossil shells. He formed a very complete collection of Scotch coins which he also presented to the Museum.

From time to time various papers and works upon Archæology, Scriptural Criticism, and Geology, proceeded from his pen, giving evidence both of the breadth of his interests, the industrious accuracy of his observations, and the acute and scholarly cast of his mind.

In the field of Scriptural criticism, he published an essay on "The Sources of St. Luke's Writings," and a work on the Voyage and Shipwreck of St. Paul. The last named work has become a standard authority upon the subject on which it treats, and is so thoroughly exhaustive that it is not probable it will ever be superceded.

Among his antiquarian papers is an account of the Vitrified Fort on one of the Burnt Islands in the Kyles of Bute, which was discovered by Mr. Smith during one of his yachting expeditions. This paper was published in the transactions of the Edinburgh Antiquarian Society.

The field of Post Tertiary Geology, however, was the favourite ground of our late President's investigations. In some degree, indeed, the name of Mr. Smith marks an epoch in the development of this branch of geological science. He was the first to maintain and prove by a long series of minute, patient, careful observations, that a colder climate preceded the present. This conclusion was not arrived at by a chance guess, as a lucky speculation, or by the happy stumbling of the foot against a fossil, but it was reached step by step, and is notable as the result of inquiries pursued with skill and devotion, and directed by a true spirit of scientific research.

Mr. Smith's earliest geological paper, entitled, "An Indication of Changes in the Elevated Beds of Sea and Land in the West of Scotland," was read to the Geological Society of London, Nov. 16th, 1836, and was followed by a series of communications on the phenomena of the elevated marine beds in the basin of the Clyde; in the course of which he pointed out the arctic character of the shells contained in the upraised clays of the West of Scotland, and drew the conclusion that the climate as well as the level of the country has changed, while also attempting a classification of the various strata.

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Mr. Smith having resided for a considerable time in the south of Europe, published accounts of the Geology of Madeira and Gibraltar, with a view to describe the changes which have taken place in the fundamental rocks of those districts during the newer pliocene or post tertiary periods. His last communication was on a Split Boulder in the Isle of Little Cumbrae, read to the Geological Society of London, Feb. 26th, 1862.

The whole of these papers have been collected and published in one volume, entitled, "Researches in Newer Pliocene and Post Tertiary Geology." *

This volume of Mr. Smith's collected papers contains the history of a discovery, and is valuable as much for the mental characteristics it unfolds as for the facts it details. It shows the patient, anxious, toilsome steps by which his conclusions were reached. We see the operation of the author's mind as he passes from observation to observation, making no effort and having no desire to assert any theory of his own against the reality of nature. Scientific work, carried on in a spirit at once so single-minded and truthful and exact, manifests qualities which are as much attributes of character as endowments of intellect. It demands the intellectual patience which can wait for results. There is a patience of the intellect which is akin to the moral patience with which the heart can upbear against long and weary delays in the fulfilment of a cherished hope. It is the patience with which a man, pressing towards discovery, fairly weighs and balances fact against fact in an even scale, whether opposing or favouring the secret tendency of his personal speculations. With patience there must also be intellectual self-denial—that is, the rare power which can deny what we *wish* to be true, for the sake of what *is* true—and abandon results, achieved, perhaps, by the toil of years, when the sacrifice is asked by a newly-discovered fact. There must be the persistent labour which can endure to work for months to ascertain matters which can be stated in an hour; and to write a volume of notes which, when completed, can be summed up in a page. And persistent labour never does justice to itself unless it is united with the high capacity of being able to confess ourselves in the wrong, and of retracting what we have once stated when we see our error, although we vainly imagine a reputation for scientific accuracy involved in the uniformity of our papers.

* Glasgow, John Gray, 1862.

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There must, moreover, be the modesty which can learn more willingly from others than assert for itself, and which can never free itself from the conviction that the best we can do is necessarily imperfect and certain to be revised.

Every man attempting to follow science will do well to cherish the modest conviction expressed by Mr. Smith when writing on the changes of the earth's crust:—"However numerous the changes; however vast the intervals; they form but one page in the voluminous history of the earth which geology unfolds. That page has been but just opened, and the few feeble characters inscribed upon it by so early a labourer must necessarily be imperfect."

The volume of our late President's researches abundantly manifests these qualities of which I have spoken—intellectual patience and intellectual self-denial; persistent industry and capacity to advance beyond first-formed conclusions, united with a modesty singularly admirable in yielding to facts as they unfolded to patient observation their exact order, and rendering to their legitimate authority a due submission—qualities which, in Mr. Smith's case, bore the fruit of a happy discovery, and in all cases render the pursuit of science a noble education of the character. The history of Mr. Smith's investigations can be briefly sketched in its salient features and chief directions.

I.—*The last changes in the relative levels of land and sea in the British Islands* attracted his study.

We must cast our minds back to the day when the presence of modern shells in localities even distant from the sea was ascribed to the tumultuous and transitory effects of water. The first step taken in advance of this notion by Mr. Smith was to point out that there are many beds in the West of Scotland which it is impossible to ascribe to violent action, and which are considerably elevated above the sea level. Shells are to be found in situ and in regularly stratified beds at levels of, 25, 50, 70, 120, 350 feet above the sea, and the elevation of the land thus becomes an ascertained fact.

In the first instance, Mr. Smith discriminated two divisions only in these beds, viz., (1), The till, for the most part without shells, and these, when occurring, fragmentary; and this "till" he ascribed to diluvial action. (2), The deposits of clay and sand, containing shells in situ and proving the elevation of the land.

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The next noticeable step was taken when Mr. Smith pointed *out signs of subsidence as well as of elevation.*

He described sections in which a marine carse clay rests upon a submerged forest. The evidences of depression proved no less conclusive than those of elevation; and the general fact was thus reached, that no single movement, whether of elevation or depression, can account for the phenomena of the post tertiary beds in Scotland.

The next problem was to examine the *date of these last changes* and ascertain if any approximate conclusion could be reached. Three points upon which calculation can be based struck Mr. Smith. (1), The position of the Roman wall in reference to the sea. (2), The rate of wearing action of the sea upon substances such as trap and sandstone of unequal consistency. (3), The signs of the first appearance of man. Upon each of these matters controversy is now busy; and it is no small honour to our President that he asked the questions which will have to be answered by a succeeding generation. It is a remarkable sign of the progressive character of his mind that, in 1862, he declared himself satisfied that changes of level have taken place since the British Islands were inhabited by man —a position at variance with his earlier convictions.

II.—Mr. Smith's researches had frequent reference to the *nature and causes of the Old Till or lower Boulder Clay.* Upon this point, as others, his opinions gradually developed themselves, and we can trace their stages in successive papers.

At first he deemed the Till diluvial in its origin, considering water, when rolled by earthquake shocks, a sufficient cause. An examination of the scratched boulders contained within the Till, which he made in company with Agassiz, compelled the conviction that they must be ascribed to glacial action, either in the shape of icebergs or glaciers. The study of the successive papers upon this subject in Mr. Smith's volume is most instructive as a lesson in the gradual growth of true conviction.

Difficulties are raised; minute details referred to; fresh examinations made; until at last the old diluvial theory is surrendered, and the action of ice taken into due account.

Mr. Smith also raised the question as to the *direction of the force* by which the Till was formed. He examined and classified the different rocks which the boulder clay near Glasgow contains, and, tracing them to their source, found they must have been swept

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from the north-west. This kind of observation is familiar enough to us at the present day, but we must never forget that the commonplace facts of one generation were the original discoveries of the preceding.

III.—The chief division under which Mr. Smith's papers may be classified, contains *his examination of the shell-bearing beds of the glacial clays on the west of Scotland.*

In his early papers, all the shell beds were classed together. They were not discriminated into groups of earlier and later date, and were only regarded as proving elevation of land, without any recognition of altered climate. Shells from the raised beaches and the older glacial clays were mixed together in one list. It was perceived that several species found fossil were not identical with living forms, but these were pronounced simply extinct, and their existence in the waters of the Arctic Sea was not suspected.

The conclusion that the species supposed to be extinct were in reality living Arctic forms was first suggested to Mr. Smith by observing the identity of many of the shells most common in the Clyde beds with those described by Lyell, as fossil, at Uddevalla, and figured in his paper on the elevation of land in Sweden, in the Philosophical Transactions for 1835.

With characteristic activity, Mr. Smith proceeded to make as complete lists as possible, both of the living shells of the Clyde and the fossils of the elevated beds; and the unknown specimens having been submitted to M. Deshayes, he observed, that the whole of those examined by him, which are still to be found recent, although not in the British seas, occur in northern latitudes. The paper read by Mr. Smith to the Wernerian Society, 26th January, 1839, was the first in which it was maintained that a colder climate preceded the present.

Further researches brought evidence that there are two very distinct deposits in the elevated marine beds, differing both in fauna and climate, and separated by wide intervals of time. Mr. Smith accordingly assorted his first catalogue into two parts—the older fossil shell bed, containing arctic species; and the younger, containing no species not found living in the present seas. Separate lists were drawn up, and the proof of climatic change became complete.

These happy discoveries, gentlemen, will connect our late President's name with the history of geology. No geological manual

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can be written without its chapter on the Glacial epoch; and the first page in this chapter must be ascribed to the hand of Mr. Smith.

Many difficulties are undoubtedly unsolved, but it is a rare honour to have been permitted to raise problems so vast as those involved in the existence of an age of ice in Scotland.

One word in conclusion. In this great city there have dwelt many good and illustrious men, whose memories are cherished with reverent regard.

Now there passes from our midst the philanthropist, whose purse has been as open as his heart, and his heart as tender as his soul devout.

Now the poet is taken from us, who learnt music in the midst of our troubled discords, and, through the inspiration of genius, could make melody of this noisy city life.

Now we lose the man, skilful, it may be, in mechanical device, cunning in hand as thought, raising a machine almost into vital existence, and producing a work of genius, as harmonious in plan and parts as a poem, out of iron and brass.

Be it our privilege, gentlemen, as inefficient but not unloving students of a great science, to remember with honour one whose life was adorned by enthusiasm for its service.

In this busy community, there is need for every varied pursuit. Star differeth from star in glory, but we may be permitted to say, that he serves his race who deepens and widens the thoughts of men; and that whosoever can make men love better and follow more faithfully even the most abstract of scientific studies, not only diffuses a pure taste which can save from baser cravings, but ennobles character, by bowing down the heart in lowlier reverence before Him who fastened the foundations of earth, and who hid the corner stones thereof, when the morning stars sang together, and all the Sons of God shouted for joy.

LXIII. Notes *on some* Fossil Crustacea, *and a* Chilognathous Myriapod, *from the* Coal Measures *of the* West *of* Scotland. By Henry Woodward, F.G.S., F.Z.S., of the British Museum.

(Plate III.)

I regret exceedingly that so long a time has elapsed since my attention was first drawn to these specimens by Mr. Farie, before communicating my remarks upon them to the Geological Society

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of Glasgow. But the delay has enabled me to obtain from Edward Binney, Esq., F.R.S. (President of the Manchester Geological Society), the loan of the original specimens of *Pygocephalus Cooperi*, described by Professor Huxley, and also those of the coal *Limuli*, from Joseph Prestwich, Esq., F.R.S., for comparison with the specimens from Glasgow.

I have minutely examined the supposed Annelide, but there seems to be no reason to doubt that it is the remains of a Chilognathous Myriapod, allied to *Julus*, and preserved in a similar manner to the specimens discovered by Principal Dawson, F.R.S., of Montreal, in the South Joggins Coal Formation, Nova Scotia.

A carefully prepared drawing of another, and much larger specimen, has been obligingly sent me by Mr. J. Young, of the Hunterian Museum, Glasgow, but I should be unwilling to determine its exact character until I had examined the original specimen. From Mr. Young's drawing, there is reason to believe it may possibly prove distinct from the specimen now under consideration.

In January, 1853, Sir Charles Lyell and Dr. Dawson read, before the Geological Society of London,* an account of their examination of the stump of an erect fossil tree in the Coal-measures of Nova Scotia, containing the remains of a reptile (the *Dendrerpeton Acadianum*, Wyman and Owen), and of a land snail, (the *Pupa vetusta* of Dawson). In December 14th, 1859,† Principal Dawson gave a full description of this earliest known terrestrial mollusk, also some new species of reptiles, and a Chilognathous Myriapod, obtained from the interior of an erect *Sigillaria* in the same coal-field.

The Myriapod is figured and described under the name of *Xylobius Sigillariæ* (Dawson); and a specimen has been presented by Dr. Dawson to the British Museum.

Similar fossil remains have been found at Kilmaurs, by Mr. Thomas Brown, in nodules of light brown coloured clay-ironstone, no doubt corresponding with the "Pennystone" ironstone of Coalbrook-dale, and the "Gubbins" of the Dudley collieries, as they appear to be characterised by similar fossil contents. In the same nodule with the best preserved specimen, are a perfect pinnule, and several fragments of a fern (the *Pecopteris abbreviata*, of Brongniart). It is extremely interesting to find this presumed terrestrial

* Quart. Journ. Geol. Soc., Vol. ix., p. 58.

† Op. cit., Vol. xvi., p. 268.

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Myriapod both here and also in America, associated with land vegetation. The evidence of land conditions to be derived from associated fossils must not, however, in this case, be too strongly relied upon, as, in the same bed of nodular ironstone concretions, are likewise found king-crabs, and other undoubted marine organic remains.

The fossil (Plate III., fig. 11) is coiled up somewhat into the form of the letter J, and is two inches in length; two lines across the widest, and one line across the narrowest segment, of which there are upwards of thirty. To the epimera of each of these segments a pair of slender feet one line in length, appear to have been articulated. Towards the more slender end of the fossil these feet can be distinctly seen—not to consist of single bristles, as in the *Annelida*, but to be composed of several articuli as in the recent Myriapoda. (Plate III., fig. 12a and 13a.) Each segment of the body, wherever sufficiently well preserved to show it, bears upon its lateral portion a slightly raised wharf, indicating the position of the pores, stomata, or tracheal openings. The segments are marked by alternate ridges and furrows, and the surface presents a somewhat rugose appearance, very different from the smooth and shining articuli of the recent *Julus*. But no soft-bodied annelide would be preserved in this condition—the body-rings of those worms which I have examined, from Solenhofen, in Bavaria, for example, being indicated rather by a stain upon the slab, than by any actual *relievo* evidence of their presence, as shown in the Kilmaurs specimens. We may then be quite sure that this fossil possessed a chitinous exo-skeleton sufficiently firm and strong to leave the impress of its numerous and well-marked articuli in the soft clay, charged with carbonate of iron, in which it was entombed, together with the foliage of land plants, the clay having, by the subsequent segregation of the iron, been converted into nodules, the nucleus of which appears to have been, in every case, some organic body.

In the best preserved specimen, the head of the animal seems to be absent, but it may possibly be discerned upon the counterpart of the half-nodule, which the author has not seen. The details of the other specimen are too obscure to be made out. I do not think the specimens of this fossil entitle us to consider it as specificially distinct from that discovered by Dr. Dawson, although a comparison of the figures may convey that impression; but it is important to record this instance as the *first discovery* of *Xylobius* in Britain.

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In the Transactions of the Literary and Philosophical Society of Manchester, recording their meeting on January 8th, 1867,* it is reported that Mr. Binney exhibited some fossil remains collected by Mr. Joseph Tindall of Huddersfield, from the lower Coal-measures near that town. Through the kindness of Mr. Binney, I have been permitted to see and examine them, but I need here only refer to one specimen. It is a remarkably good example of *Xylobius* in a nodule of clay-ironstone, having about 46 well preserved articulations to its body, but, like those which I have seen and examined from Kilmaurs, it is apparently destitute of a head. This specimen shows the segments to have been ornamented with transverse finely undulating lines (Plate III., figs. 13 and 13a.), as noticed in the Nova Scotian specimen, and confirms me in the opinion that it is referable to the same genus and species. Dr. Dawson's diagnosis of the Nova Scotian fossil is as follows :—

"Body crustaceous, elongate, articulate, when recent cylindrical or nearly so, rolling spirally. Feet, small, numerous; segments, 30 or more; anterior segments smooth, posterior with transverse wrinkles, giving a furrowed appearance. In some specimens traces of a series of lateral pores or stigmata are seen. Labrum (?) quadrilateral, divided by notches or joints into three portions. Mandibles two-jointed, last joint ovate and pointed. Eyes, 10 or more on each side."†

It will probably not be without interest to record here the instances already known of the occurrence of true INSECTS in the Coal Formation.

NEUROPTERA.

1. *Corydalis Brongniarti* (wing of), in Clay Ironstone nodule. Coalbrook-dale.
   [Brit. Mus. Collection. Mantell, Medals. p. 578. Murch. Sil. Syst., p. 105, f. 13a.]

COLEOPTERA—*Rynchophora.*

2. *Curculioides Ansticei*, Buckl. Nodular Ironstone, Coalbrook-dale.
3. *Curculioides Prestvici*, Buckl. Do. do. do.
   [See "Buckland's Bridgewater Treatise" on Geology, vol. ii, p. 76, t. 46, figs. 1 and 2.]

MYRIAPODA—*Chilognatha.*

4. *Xylobius Sigillariæ*, Dawson, 1860. Coal M., Nova Scotia.
   [Quart. Journ. Geol. Soc., vol. xvi., p. 268. a specimen in British Museum.]
   ——— ———. Coal Measures, Kilmaurs, Glasgow.
   ——— ——— Lower Coal Measures, Cooper's Bridge.

* See Geol. Mag. for March, 1867, p. 132.

† Quart. Journ. Geol. Soc., 1860, Vol. xvi., p. 272.

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ARACHNIDA—*Scorpionidæ.*

5. *Microlabis Sternbergi*, Corda. Coal M., Bohemia.
[Original in the Prague Museum, Cast in the British Museum.]

6. *Cyclophthalmus senior*, Corda. Coal M., Bohemia.
[Original in the Prague Museum. Cast in the British Museum. Figd. in Buckland's Bridgewater Treatise, vol. ii, pl. 43 and 46*.]

ARACHNIDA—*Araneidæ.*

7. *Aranea* ——— Coal Shale, Bohemia.
[Original in Prague Museum, Cast in British Museum.]

8. *Protolycosa anthracophila*, Roemer. Coal Measures, Upper Silesia.
[See Geol. Mag., 1865, vol. ii., p. 468.]

In the foregoing list, then, we have 8 species of land-dwelling, air-breathing *Articulata*, representing 4 orders of *Insects*, 2 orders of *Arachnida*, or spiders and scorpions.

Among the insects it is interesting to notice one form at least (the *Corydalis Brongniarti*), possessed of the highest attribute of the class at the present day, namely, the power of aerial locomotion. It conveys to our mind a wonderful subject for consideration, that at this remote period so great an approach to the present condition both of the terrestrial surface of our globe and the atmosphere enveloping it, should have been arrived at, that even on the very imperfect and limited information we possess, we should be able to note amphibian reptiles, a land snail, and nine kinds of land-dwelling *Articulata*.

Since the description of *Xylobius* was written, the author has received Vol. I. of the tenth edition of the "Principles of Geology," by Sir Charles Lyell, Bart., in which, at chap. ix., p. 157, is the following :—

"Up to the year 1865, only a few insects had been obtained even from the Carboniferous strata, the land-plants of which are well known to us, and none from the Devonian. From this last formation, several have now been brought to light in North America, chiefly of the order *Neuroptera*, found by Mr. Hartt, in rocks near St. John's, New Brunswick, and determined by Mr. Samuel Scudder, of Boston, U.S. Why, then, should we despair of finding in our future researches some air-breathers of a much higher order than insects which may have peopled the forests of the Devonian era, in which pines, *Sigillariæ* and *Lepidodendra*, or gigantic *Lycopodiaceæ* flourished."

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In the sixth edition of the "Elements of Geology," by the same author, at chap. xxiv., p. 491, is the following notice:—

"More recently (1854) Mr. Fr. Goldenberg has published descriptions of no less than twelve species of insects from the nodular clay-ironstone of Saarbrück, near Treves.* They are associated with the leaves and branches of fossil ferns. Among them are several *Blattinæ*, three species of *Neuroptera*, one beetle of the *Scarabæus* family, a grasshopper or locust, *Gryllacris*, and several white ants or *Termites*. These newly-added species probably outnumber all we knew before of the fossil insects of the coal."

The following is the list of species described, copied from the original work:—

I. Order—ORTHOPTERA. 1 Fam.—BLATTIDÆ.	
Blattina primæva,	F. Goldenberg.
——— *Lebachensis*,	——
——— *gracilis*,	——
2 Fam.—LOCUSTIDÆ.	
Gryllacris lithanthraca,	——
3 Fam.—TERMITIDÆ.	
Termes Heeri,	——
——— *formosus*,	——
——— *Decheni*,	——
——— *affinis*,	——
II. Order—NEUROPTERA. 1 Fam.—SIALIDÆ.	
Dictyoneura anthracophila,	——
——— *Humboldtiana*,	——
——— *libelluloides*,	——
III. Order—COLEOPTERA. 1 Fam.—TROCHIDÆ.	M'Leay.
Troxites Germari,	F. Goldenberg.

In all, 3 orders, 5 families, 5 genera, and 12 species, all from the Coal formation of Saarbrück, Rhenish Prussia.

At the risk of becoming tedious, I beg to be allowed to append one more additional note upon Fossil Insects, just received from Dr. Dawson, F.R.S., of Montreal, (Proceedings Montreal Nat. Hist. Soc., April 29, 1867,) see Geol. Mag., August, 1867, p. 374.

Dr. Dawson here gives an account of a new genus and species of Neuropterous insect from the coal shale, Cape Breton, and of four other genera from the Devonian shales of St. John's, New Brunswick, with descriptions prepared by Mr. Samuel Scudder, Curator of the Boston Natural History Society's Museum.

* Palæontographica, Dunker & V. Meyer, 1856. Band iv., pp. 17-38. Tab. iii.-vi.

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The new Neuropterous insect from the coal is named *Haplophlebium Barnesii*, Scudder, and must have measured fully 7 inches in expanse of wings.

The Devonian insects are:—

Platephemera antiqua,	Scudder.
Homothetus fossilis,	Scudder.
Lithentomum Harttii,	Scudder.
Xenoneura antiquorum,	Scudder.

These latter have been already referred to at p. 238, in our extract from the 10th edition of the "Principles."

On the CRUSTACEA *from the* GLASGOW COAL FIELDS.

I. THE oldest order of this class represented in the series of specimens before me, is the King-Crab *(Xiphosura)*. Of this order, there are representatives of two genera:—1. *Belinurus*, Baily; 2. *Prestwichia*, H. Woodward.

In a paper on the relations between the *Eurypterida* and the *Xiphosura*, read before Section D. (Biology) of the British Association at Nottingham, 1866, and in another paper subsequently communicated to the Geological Society of London,* I have divided the *Limulidæ* or *Xiphosura* into three genera:—

1st. *Belinurus*, having five free and moveable thoracic segments (immediately succeeding the head-shield), and 3 coalesced abdominal segments, to which the telson or tail-spine is attached.

2nd. *Prestwichia*, in which the thoracic and abdominal segments are anchylosed together, but the divisions of the coalesced segments can still be distinguished on the dorsal surface.

3rd. *Limulus*, in which the thoracic and abdominal segments are entirely blended together in one post-cephalic covering.

The two former genera only occur in the Coal Measures; the last named genus appeared first in the upper white Jura of Bavaria (lithographic stone), and thence continued to exist up to the present day, with probably but slight variation in its structure.

The specimen of *Belinurus*, which I identify with *Belinurus trilobitoides*, is enclosed in the half of a nodule of clay ironstone from Kilmaurs; and, though small, is one of the best preserved specimens I have seen. (Plate III., fig. 10). Its total length is fifteen lines,

* See Quart Journ., Geol. Soc., Feb., 1867. Vol. xxiii., pl. i. and ii., pp. 28-37.

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of which the head is five lines; the thoracico-abdominal segments, four lines; the telson, six lines. The greatest breadth of the head is eleven lines, or more than twice as wide as long.

The type of *B. trilobitoides*, Buckland, sp., from the Clay Ironstone (Pennystone), of Coalbrook-dale, is not by any means so well preserved as the Kilmaurs specimen, though the former is somewhat larger.

The original specimen will be seen indifferently figured in "Buckland's Bridgewater Treatise" on Geology—(Vol. 2., p. 77; tab. 46, fig. 3.) The specimen itself was presented during last year by the late Mr. W. Anstice, of Madely Wood, to the British Museum.

I hope to be allowed the opportunity to figure this Kilmaurs example for the Palæontographical Society's Monograph on the *Merostomata*, when I come to the division *Xiphosura*.

II. The second genus, *Prestwichia*, is represented by the impression and counterpart of a specimen in Clay Ironstone, also from Kilmaurs; and is referable to *Prestwichia rotundata*, H. Woodw. (Plate III., fig. 8.) It was first noticed as *Limulus rotundatus*, by Mr. Prestwich, who discovered and figured it in his masterly paper on the Geology of Coalbrook-dale.*

The original specimen was referred by Mr. Prestwich to Professor Milne-Edwards, who considered it to be a distinct species; and pointed out the curious membrane-like border to the thoracico-abdominal segments which connects them together.

"The membrane connecting the spines and the circular outline," observes Mr. Prestwich, "are considered to be peculiar."

The circular outline was, however, much aided by the *absence*, in Mr. Prestwich's example, of the cheek-spines, so prominently seen in the Kilmaurs specimen. (Plate III., fig. 8.)

The dimensions of the specimen differ but little in other respects from Mr. Prestwich's type example kindly lent me by that gentleman for comparison, and figured on our Plate. (See fig. 9).

Mr. E. Hollier, of Dudley, sent me in August, 1866, for examination, another well-preserved example of *P. rotundata*, also exhibiting the extremely long cheek-spine.

I have elsewhere † described in detail the points of structure in

* Trans. Geol. Soc., 1840—2nd Series, vol. v., p. 41, figs. 5-7.

† Brit. Assoc. Reports, Nottingham, 1866, edited by Dr. Robertson; also Reports of Sections, published by the Association; see also Quart. Jour. Geol. Soc., for February, 1867.

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Limulus, recent and fossil; and the entire group will, in due course, appear in the Monographs of the Palæontographical Society. I shall not, therefore, say more here; but briefly refer to the other forms of Crustacea which have been submitted to me.

III. *Pygocephalus Cooperi*, Huxley. The next Crustacean I identify with the *Pygocephalus Cooperi* of Huxley (Plate III., figs. 1 and 2), described in the Quart. Journ. Geol. Soc., London, 1857, vol. xiii., p. 363, plate xiii. As I have frequently before observed, in the examination of various genera and species of Crustacea from the Solenhofen Limestone, etc., etc., certain species, in dying, always appear to have assumed a particular position—gathering their mantle around them decently, like Cæsar, when assassinated. Certain others, *after death*, appear always to break up in a systematic manner. *Ceratiocaris* is generally found in the Upper Silurian of Lesmahagow, with its tail in its mouth. *Trimerocephalus*, in the Devonian of Newton, always has its head directed towards its tail, and *detached*. Again, one species of Crustacean always occurs with the dorsal aspect exposed upon the matrix; another as invariably presents the ventral. Thus, in *Pygocephalus*, the specimens described by Professor Huxley, in the paper above referred to, have the ventral aspect exposed to view, whilst the dorsal adheres as firmly as possible to the matrix.

Both the specimens from Bilston, and Medlock Park Bridge, Manchester, and the impression and counterpart from Kilmaurs, exhibit the ventral aspect, and closely agree in general appearance. The only additional point of structure which a long and careful examination of the Manchester specimens and the example from Kilmaurs enabled me to detect, has been in the structure of the abdominal segments, and the tail-lobes.

I am able to detect four abdominal segments, and the form of the broad lateral tail-lobes, in the Kilmaurs specimen. (Plate III., fig. 2).

The Manchester example (Plate III., fig. 1), also exhibits the same character, though less distinctly.

Professor Huxley has clearly shown, from the character of the thoracic appendages and the sterna of the thoracic somites, that *Pygocephalus* must be placed near to *Mysis* (the opossum shrimp), among the lower *Decapoda*; but I do not think it has any affinity for the *Stomapoda*, which is the group suggested by him as the

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alternative. The only supposed points of resemblance to *Squilla*, in the abdominal somites and caudal fin, disappear when more clearly seen by the additional light afforded by the Kilmaurs specimen; and we are convinced that its affinities are with the higher group. In the transversely divided, half calcareous, half membranous, character of the caudal laminæ, we are reminded of the tail-plates of *Thenus* and *Scyllarus*; and upon comparing the sterna of the thoracic segments in *Scyllarus arctos* (Plate III., fig. 4), the same increase in the width of the posterior segments is observable as in *Pygocephalus*.*

The following is a brief description of *Pygocephalus Cooperi* (Plate III., figs. 2 and 3), in which I have, as nearly as possible, followed Professor Huxley's paper. The *antennules* present two subcylindrical basal joints; the *antennæ* have two large basal joints, giving attachment to a broad oval scale externally and superiorly; while internally, the fusiform base of the internal division of the antennæ is formed by three joints, with the last of which a very long multiarticulate filament is continuous.

The cephalo-thorax has seven pairs of appendages (corresponding, no doubt, to the five pairs of limbs in the ordinary Decapod), and two pair of the external mouth organs (maxillipeds), which, in many of the Macroura, are as large and prominent as the true walking feet. Each limb consists of two parts—the limb proper (or endopodite), and a many-jointed filamentous appendage (or exopodite), which is nearly as large as the limb itself (as in the living *Mysis*).

The segments of the abdomen are well developed and have their epimera produced to a point as in *Scyllarus, Astacus*, &c., not rounded as in the *Palæmonidæ* or undeveloped as in *Mysis*.

The transverse division of the laminæ of the tail can be very distinctly seen in the example from Kilmaurs; but this, like the Manchester specimen, serves to throw no additional light on the carapace.

IV. Another specimen, believed to belong to the same species, was found by the Rev. William Fraser, M.A., in the lower Coal-measures of Paisley; and is figured and described by Professor Huxley, in Quart. Journ. Geol. Soc., Lond., 1862, vol. xviii., p. 420. As it presents a side view of the Crustacean, and all the other specimens

* The sternum of many other Macroura exhibits the same character.

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exhibit the ventral aspect, it remains still a very difficult question to decide whether they are really specifically identical.

By the kindness of the Secretary of the Geological Society of London, I have been allowed the use of the original woodcut above referred to, which I here subjoin.

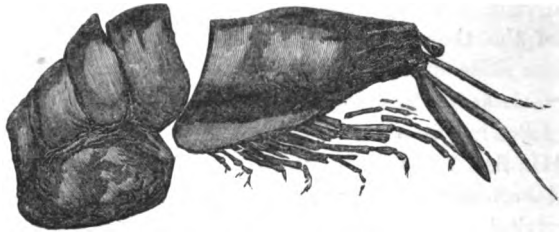

FIG. 1. ORIGINAL FIGURE OF PYGOCEPHALUS (?)
(See Quart Journ. Geol. Soc., London, vol. xviii., p. 421.)

There are two points, however, which appear to indicate distinct characters between the Paisley Crustacean (Plate III., fig. 3),* and the Manchester and Kilmaurs specimens (Plate III., figs. 1 and 2). Professor Huxley suggests (op. cit.) that the interval between the posterior border of the carapace, and the first obvious abdominal segment (see woodcut, fig. 1), was once occupied by the small true first abdominal segment, not much more than half the size of the others. I, however, feel satisfied that the first visible segment is the true first abdominal segment; that the supposed third and fourth segments are really one, and, together with the subjacent portion, form one continuous enamelled surface without any break, thus making the second a large overlying saddle-shaped segment, having a broadly-rounded epimeral border, corresponding with the second segment in the *Palæmonidæ*, which is always larger than the first and third somites.

The subjoined woodcut (fig. 2) is intended to show this altered interpretation, which I venture to offer, of this interesting specimen. I may state that I submitted the original to long and careful examination by myself, and also obtained the opinion of my colleagues, Mr. G. R. Waterhouse and Mr. W. Carruthers, before I ventured to offer this revised outline of the abdominal segments.

* We regret that the artist has failed to convey in this figure a clear idea of the segments, but the woodcut, fig. 2, will supply the deficiency.

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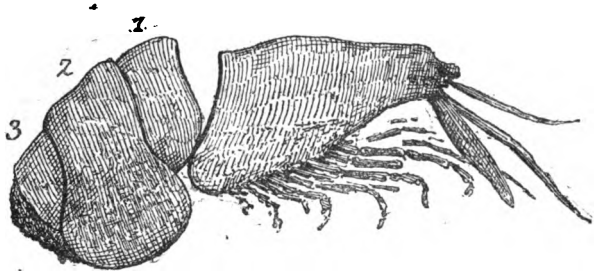

FIG. 2. PYGOCEPHALUS HUXLEYI. H. WOODW.

(Re-drawn from the original specimen in the collection of the Rev. William Fraser, M.A., from the Clay-ironstone of the lower Coal-measures, near Paisley.)

The broad oval scale attached to the antennæ in *Pygocephalus Cooperi*, is long and narrow in the Paisley example (nearly five lines in length). The *Mysis*-like limbs, and the form of the carapace, however, favour their near relationship. Fully believing in its specific, if not generic distinctness, I propose to name it *Pygocephalus* (?) *Huxleyi*, in honour of the original describer.

V. *Anthrapalæmon*, Salter, 1861; Quart. Journ. Geol. Soc., vol. xvii., p. 530. *Palæocarabus*, Salter, 1863; ib., vol. xix., p. 520. Plate III., figs. 5, 6, and 7.

The remaining form to be noticed is that of a Macrourous Decapod Crustacean, found in "Mushet's Black-Band" Ironstone, at Chapel Hall, Airdrie, by Mr. James Russell, and described by Mr. J. W. Salter under the above names.

The earliest known example of this division of the class Crustacea, in the Coal Measures, was obtained by Mr. J. Prestwich, from the "Penny-stone" Ironstone of Coalbrook-dale, Shropshire, and was referred by Dr. Milne Edwards, who examined it, to the *Phyllopoda*, under the name of *Apus dubius* (Trans. Geol. Soc., Lond., 1836, 2nd series, vol. v., p. 413). In 1844 some further remains of this genus were noticed by W. Ick, Esq., F.G.S. (Quart. Journ. Geol. Soc., Lond., vol. i., p. 199). We are indebted to Mr. Salter for the first correct account of these Crustacea in 1861, when he figured the almost entire form from a specimen in the collection of Dr. William Grossart, obtained in the "slaty black-band," 960 feet below the "Ell-coal," at Goodhock Hill, Shotts, Lanarkshire. For this form Mr. Salter proposed the genus *Anthrapalæmon*, a name which, as he observes, "has only a general signification, and is not intended to

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indicate a real relation to *Palæmon*," to which genus it has not the least resemblance or affinity.

Mr. Salter also proposed for the Coalbrook-dale form (*Apus dubius*, of Milne Edwards) the sub-generic appellation of *Palæocarabus*. This sub-genus was subsequently (June, 1863) erected into a genus by the same author, and a new species described under the specific appellation of *Russellianus*. I have carefully examined the specimen figured by Mr. Salter (Quarterly Journal, Geol. Soc., Lond., vol xix., p. 520., fig. 1,) which is now in the British Museum, with reference to his description; and I am compelled to conclude that Mr. Salter has been in this instance misled by the displacement of the antennary organs, and that which he has described as the antennæ are, in truth, *the antennules*, and the so-called antennules are the true antennæ.

I am further confirmed in this view by another specimen of *P. Russellianus*, kindly placed in my hands by Professor Huxley, and which I have had figured on the plate (Plate III., fig. 7). By referring to this figure the antenna will be seen (*b b*) almost in their normal position, and one of the antennules (*a*) with its bifid filamentous termination, also remains *in situ*.

If further proof were needed of the correctness of this view, I would simply add, that in all the recent Macroura with which I am acquainted, I know of none in which the antennules are large and simple, and the antennæ small and bifid, the converse being always the case.

As far as the specimens at present found enable me to judge, I see no good grounds upon which to establish two genera on these crustacean remains from the ironstone. The carapaces of both *A. Grossartii* and *P. Russellianus* are similarly ornamented upon their surface, the number of serrations on the margin is the same in both, the rostrum appears to be the same, and the position of the lines dividing the regions of the carapace is alike in both genera; the only differences being apparent, not real, and due rather to mineralization and similar causes. *Palæocarabus* should, therefore, in my opinion, be treated as a synonym of *Anthrapalæmon*, the latter name having two years' priority.

It is so extremely rare to obtain really good crustacean remains in the Coal-measures, that I have been much pleased to be allowed to examine the beautiful little carapace of *Anthrapalæmon*, drawn on the Plate (Plate III., figs. 5 and 6), from Airdrie.

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The foregoing brief notice of Carboniferous Articulata which I have submitted would be little worthy a place in the Transactions of this Society, but for the hope that it may induce some of its members to take up more energetically than hitherto the search for insect remains in these Carboniferous ironstone deposits, so rich in fossils, and which have already revealed to us, in our own country, the presence of *Neuroptera*, *Coleoptera*, and *Myriapoda*, and may afford us many more evidences of terrestrial conditions in Palæozoic times.

EXPLANATION OF PLATE III.

Fig. 1. *Pygocephalus Cooperi*, Huxley—natural size—drawn from the original specimen preserved in the Manchester Museum, found in an Ironstone nodule, imbedded in Coal-shale, Medlock Park Bridge, Ashton-under-Lyne. [See Prof. Huxley's paper, Quart. Jour. Geol. Soc., Lond., 1857, vol. xiii. p. 363, plate xiii.]

Fig. 2. *Pygocephalus Cooperi*, Huxley. Coal measures, imbedded in nodule of Ironstone, Kilmaurs, Ayrshire.

Fig. 3. *Pygocephalus Huxleyi*, H. Woodward. Lower Coal-measures, in ironstone nodule, Paisley. [See Prof. Huxley's paper, Quart. Journ. Geol. Soc., Lond., 1862., vol. xviii., p. 420.] See woodcuts, p. 244 and 245.

Fig. 4. Sterna of thoracic somites of a recent crustacean, *Scyllarus arctos*, Linn., for comparison with figs. 1 and 2.

Fig. 5. *Anthrapalæmon Grossarti*, Salter, carapace of (natural size). Coal measures, Airdrie.

Fig. 6. The same enlarged.

Fig. 7. Portion of another specimen from Airdrie, now in the Museum of Practical Geology, Jermyn Street, showing one of the bifurcated antennules *(a)* and the two simple antennæ *(b, b)*.

Fig. 8. *Prestwichia rotundata* (natural size). Coal-measure Ironstone, Kilmaurs, Ayrshire.

Fig. 9. The original specimen of *Limulus rotundatus*, Prestw. re-drawn. [Trans. Geol. Soc. Lond., 2nd Ser., t. 41, f. 5-7.] Clay Ironstone ("Pennystone") Coalbrook-dale, Shropshire.

Fig. 10. *Belinurus trilobitoides*, König. (natural size), from Kilmaurs, in a nodule of Clay-ironstone.

Fig. 11. *Xylobius Sigillariæ*, a chilognathous myriapod, allied to *Julus*, from Coal-measure Ironstone, Kilmaurs Ayrshire (*h* anterior end of specimen).

Fig. 11*a*. Three of the Segments enlarged (showing the tracheæ [t.] ?).

Fig. 12. *Xylobius Sigillariæ*, Dawson, found associated with *Pupa vetusta* in the hollow trunk of a Sigillaria in the Coal measures of the South Joggins Coal formation, Nova Scotia.

Fig. 12*a*. Copy of Dr. Dawson's figure representing a magnified portion of the body with the lateral pores. [See Dr. Dawson's paper, Quart. Jour. Geol. Soc., 1860, vol. xvi. p. 271, figs. 4-9.]

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Fig. 13. Mr. Tindall's specimen of *Xylobius Sigillariæ*, from Clay-ironstone band Coal-measures, Cooper's Bridge (drawn of the natural size; *h* head).

Fig. 13*a*. Portion of body of same magnified, showing the legs (as seen under the microscope with a 2-inch lens).

NOTE.—From a careful study of the specimen of *Xylobius Sigillariæ*, from Nova Scotia, in the British Museum, I am convinced that Dr. Dawson's figures—figs. 12 and 12*a*—are intended to be only diagrammatical; the specimen presents much the appearance represented in fig. 11.

LXIV. *On the* IGNEOUS ROCK SECTIONS *at the* RYE WATER, AYRSHIRE. By R. WHYTE SKIPSEY.

(Read January 17, 1867.)

THE length of this stream, taking Blairpark, which is about equidistant from Largs and Kilbirnie, as a starting point, may be roundly stated as seven miles to the town of Dalry. Its course, for the first 2½ miles to the Howrat toll-bar is south-east, from whence it runs south for about two miles, and then taking a sharp turn, almost at a right angle, shortly resumes nearly its former course of south-east into Dalry.

Its upper reaches run nearly along the line of the Largs and Kilbirnie road as far as the toll-bar above mentioned, but it has comparatively little interest for the geologist, as the ground through which it winds its course, although of igneous character, is generally covered with verdure and wanting in any marked features to attract attention. I therefore confine the description to about two miles of the stream below the toll, where the first important section of volcanic rocks occurs, to the upthrown strata of the carboniferous system, about 2¼ miles from Dalry, where it again ceases to possess any novel or more marked character.

As developed at this first section below Howrat toll-bar, water and weathering have worn out considerable cavities, and there are in succession, from the water surface, or rather a little under it, beds of hard porphyritic greenstone, trappean ash, eight feet thick, of a blackish grey colour, graduating into a plain compact amorphous greenstone, ten feet thick, capped by eight feet of dolerite, being a well-defined prismatic trap of rhomboidal form, the whole of these beds being nearly in a horizontal position.

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Half a mile farther down another fine outbreak occurs. The beds from the water are successively porphyritic greenstone, and trappean ash, both these varieties being repeated, and all of them somewhat disturbed in position, although not greatly off the horizontal. But the most interesting feature is a dyke of compact blue trap 40 feet broad, vertically intersecting all these beds to the surface, its line being from west to east. It appears on one edge, cutting through the other rocks as straight as a wall, and on the other is oblique, carrying the upper deposits of greenstone and ash on its shoulder, the beds at a very short distance again resuming their natural level; and I wish the position of this intrusive rock kept in view, as I shall afterwards notice the bearing I consider it to have on the upthrow of the ironstone to the westward.

The rocks continue to exhibit this somewhat regular order of deposit, and the same characters, while at one point about a quarter of a mile lower, they are intersected by two remarkable thin beds of hard greenstone, at an angle of 25 degrees, which visibly cut the upper compact greenstone and upper ash bed; but they may not be posterior intrusive ejections, but simply the result of a disturbing upheaval, where the acting power is still invisible. The surface of the ground here distinctly shows considerable deposition of boulder drift.

About three-fourths of a mile below the last described section another occurs, and though the locality had been as barren of other attractions as it is rife of them, this spot alone is one of the finest studies the physical geologist could possibly desire. It is a bold, vertical cliff, of 80 feet in height, from the bed of the burn to the surface, exhibiting a most singular succession of alternations of trappean ash and compact greenstones. Commencing with the water line there are 2½ feet of hard ash, 2½ of soft and friable ash, 1 of hard, 4 of soft, 1½ of hard, 3 of soft, these changes continuing upwards for some distance, till it is capped by a compact greenstone, the beds of harder ash in some instances assuming the character of solid trap. But an actual visit to the locality is the only way to understand this remarkable example of our igneous rocks.

There is another kindred rock found to which I cannot assign a fixed place. It is light purple, with darker spotting of same colour, similar to that found extensively in the Ochill range at Blair Logie, and was long distinguished as Porphyry, or Clay

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Porphyry. Rock of this character was formerly used in the manufacture of china ware. It is now classed as Felspar Porphyry.

It is only to be found in detached pieces, often rounded by attrition; and as it occurs both in larger fragments and greater quantity in the higher parts of the stream, I regard its normal position as somewhere in the hilly ground nearer the source, where, though covered with verdure, it would likely be found in some little knolls as a posterior outburst of molten matter to the rocks round it. This appears to be the relation of the similar rock in the Ochills.

Immediately below the section I have last noticed, the stream takes the sudden and short turn to the east already referred to, and the igneous deposits become suddenly arrested by an immense vertical upthrow of carboniferous limestone beds and their concomitant shales, which abut against the trap and ash like a dead wall, as high as the igneous rocks themselves.

This occurs on the north side of the stream, continuing for some hundred yards; and the same calcareous strata are thrown up to the surface on the opposite or south bank, although the lower end of the upthrow, as far as visible, is only to the extent of the sandstones and shales overlying the black band ironstone, these shales being only partially fossiliferous.

Invisible as the agent in this large upheaval is, there can be little doubt of its being an extensive trap dyke of posterior date. Some portions of the limestones and other strata show clear signs of induration and other alterations of their normal characters, and the 40 feet trapfault I have already drawn attention to, forms a good example, on a small scale, of this more extensive upthrow, as in both cases one edge cuts the superincumbent deposits clean through, or entirely disunites them, the other only uplifts them on its shoulder to the extent, at least, of the upper portions.

As this communication is intended mainly to apply to the igneous portions of the locality, there is no need for details as to the carboniferous strata, the general character of these being well enough known; but I may state that the Blackband ironstone partially appears at the lower end of the upthrow of sandstone and shale, and a pit of this metal is wrought about half a mile north-west 50 to 60 fathoms deep, while some little distance farther in the same direction the metalliferous beds (in mining language) "crop out" at the surface.

A "crop out" does not always imply a violent upthrow from

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volcanic or earthquake influences, being sometimes the result of extensive denudation of a sloping or angular character, but in this case, as the rise of the ironstone beds lies to the westward, and in something like the direct line of the 40-feet fault across the burn, I regard it as one of the direct results of this intrusive and posterior trap dyke.

The simple minerals disseminated in these rocks are not very varied, and consist of the usual nodules and veins of calcareous spar and quartz, with some fair examples of white and red stilbite, small white prehnites and fine pellucid quartz, approaching in character that of hyalite. Anticipating a natural question, what are the relative positions of these various beds of trap and ash? I may state that in such deposits, as well as in the more regular stratification of our carboniferous system, it is sometimes the case, that in the same line, one class of rock, or other indurated material, is suddenly cut off, and another, in continuation, takes its place. Assuming, therefore, that the Rye Water district may not be altogether an exception to this rule, and also that disturbing forces may have caused some smaller dislocations, I am strongly inclined to the conclusion, that the whole of the often repeated deposits of thin trap beds and ash at the lowest section I have described, underlie, as their true normal position, the upper sections taken from the water's edge, or at least sections from the amorphous greenstone at this point, although the broken and denuded intervals prevent fully tracing this out; because though the stream is neither rapid, nor having much fall as a whole, yet the slope is sufficient, combined with the abrupt breaks occurring in the line of the water at different points, to render this opinion of relative position a probable one; and a closer examination than I had it in my power to make, would be both pleasant and instructive.

Judging from the levels and mineral character of the ground at and near the lime quarry, it is not improbable that the stream there, at a former period, nearly approached the level considerably higher up, that it had then been more widely spread over, with a course for a short distance partially different; and this view appears the most legitimate to account for such total denudation of all other strata at the point, the fossiliferous Limestone being to the very surface, except a few feet of alluvium.

Some of the pools at the upper sections are of a circular form and considerable depth, partly owing to the continuous action of wate

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on materials like trappean ash, liable to rapid waste; but this destructive process is greatly facilitated by circular masses of hard trap, occasionally enveloped in the softer rock, as well as by detached pieces of undetermined form falling away from the surrounding mass, and which, when not lying perfectly solid, are kept in motion by the water, and exercise an immense abrading power. They are occasionally seen still in these hollows, but often wear out a path at the lower ends of the pools, and are gradually carried onward by the current.

LXV. Scottish Geology—*its Proofs and Problems.* By David Page, Esq., F.R.S.E., F.G.S.

(Read October 20th, 1867).

Abstract.

The author stated that by its *proofs* he meant what was known, or at least generally admitted, by competent geologists; and by its *problems* what was still doubtful and required further investigation. His object was not to sketch the history of Scottish Geology, which, about the beginning of the century, was a mass of theories and disputations between Wernerians and Huttonians, and which at a later period was little else than a nomenclature of rocks and minerals; but he could not avoid mentioning the names of such men as Hutton, Playfair, Ure, Sir James Hall, M'Culloch, Williams, and Jamieson, as contributing largely, even amidst these unproductive discussions, to the progress of the science. Legitimate geology could date back little more than thirty years, and during that period its advancement in Scotland was indebted in no small degree to the labours of Fleming, Smith, Cunningham, M'Laren, Hugh Miller, and especially to those of Lyell, Murchison, Nicol, Geikie, and others who were still steadily endeavouring to unravel its many complicated physical as well as palæontological problems. He then took in review the various stratified systems, from the Laurentian up to the most recent accumulations, pointing out the known from the unknown, and from the doubtful or what required more minute investigation. Admitting the existence of Laurentian strata in the Hebrides and northwest corner of Scotland, it still required investigation to determine whether these were the true equivalents of the rocks of the St. Laurence, or were merely a set of gneissic schists

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and quartzites of somewhat higher antiquity than those of the mainland. The Cambrian rocks of the north-west being also admitted, it likewise required further research to develop their fossils, and coordinate them with the lower slates of Wales and the Huronian series of North America. Lower, middle, and upper Silurian beds had now been established in the South of Scotland; but it had not yet been attempted to lay down these respective zones on our maps; nor had any one yet succeeded in establishing the order of succession among the schists of the Northern Highlands, though they had been coloured in some sketch maps as metamorphosed Silurians. The order of succession, he thought, was evident, and only required careful surveys to establish it; nor did he altogether despair of yet finding fossils among the less metamorphosed slates and limestones of that formation. Passing on the Old Red sandstone, which was largely developed in Scotland, and consisted of three well-marked divisions, there were several problems, he considered, still unsolved connected with that classical formation. In the first place, the Old Red sandstone of Scotland could not be coordinated with the Devonian of England, but was an older formation, and altogether different both in lithology and palæontology; in the second place, it was still undecided whether the lower Old Red was of fresh water or marine origin; and in the third place, the three divisions were not yet fully and fairly made out in the northern districts of Scotland. The origin of the Old Red conglomerates was also undetermined; and while the Devonshire strata might be coordinated with the upper Old Red of Scotland, or perhaps with part of the lower Carboniferous, they could never, and ought never, to have been regarded as the equivalents of the Scottish Old Red—the name "Devonian," being altogether a misnomer when applied to the elder formation. Adverting next to the Carboniferous system, to which Britain owed so much of her mechanical and commercial greatness, there were many problems of climate, fossil botany, and local vulcanicity still unsolved; and though much had been done of recent years to reveal the successions of the strata, the boundaries of the coal-fields were not yet sufficiently determined, nor had care been taken to mark the distinction between eruptive traps which disturbed or destroyed the coal-beds and interstratified traps, beneath which some of our best coal seams lay unbroken and unaltered. Our maps and sections also required revision, for while the outcrops of coals and ironstones and limestones were noted,

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those of the oil shales (which had recently become of paramount value) were passed over unmarked, as altogether worthless and unproductive. The coal measures, he said, closed the true succession of stratified systems in Scotland; but in some districts the Secondary and Tertiary strata appeared in sporadic patches, and these on the whole required more care and investigation than they had hitherto received. He alluded to the Permain and Triassic (new red sandstone) beds of Ayrshire and Dumfriesshire; to the Lias and Oolites of Skye, Eathie, Brora, Linksfield and Banff; to the chalk-flints of Buchan; and to the Miocene leaf-beds of Mull—all the fragmentary representatives of the broad and well-developed Secondary and Tertiary systems of England. Passing next to the Glacial Drifts, he admitted the determination of three well-marked stages—the lower "Till" or true boulder clay, the middle bouldery and gravelly drifts, and the upper brick-clays—Kames and Moraines; but advised attention to the search of pre-glacial deposits, which were not uncommon, as well as to certain surface clays and gravels whose origin yet remained a perplexing but most interesting problem. As to recent formations, he directed attention to the prehistoric barrows, shell-mounds, crannoges, and bone-caverns of the country, which had yet received little or no attention, as compared with those of England and the adjacent continent of Europe. He recommended the laying down of the superficial accumulations on a different set of maps from those of the stratified system, as interesting at once to the man of science, and useful to the engineer, farmer, and landscape gardener. As to the scenery of Scotland, that, in his opinion, was the result of many and complex causes which had operated from the time of the Silurian upwards—submergence and upheavel, marine denudation and meteoric waste, ice on land and ice on water, rain and rivers—and he who would attempt to ascribe it to one cause or to one period alone, read the record of the past with little insight and less reflection. The author then adverted to the Igneous Rocks, noting several problems in connection therewith well worthy of the Society's attention. Among the chief of these were the origin of the granites, whether igneous or metamorphic; and if metamorphic, whether metamorphs of aqueous or of igneous compounds. The origin of many of the traps, whether consolidations from fragmentary ejections or from molten fusion? The relatives ages of the Porphyries, Felstones, and Greenstones? The age of the later Basalts? And whether there

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were any evidence of faultings or volcanic disturbance in Scotland since the close of the Glacial epoch? Mr. Page concluded by complimenting the Geological Society of Glasgow on the substantial work it had done, and the great progress the individual members had made since 1858, but cautioned them to extend their surveys, if possible, beyond their own Carboniferous and Clyde-bed area.

LXVI. *On the* Silurian Scenery *of the* Enterkin. By John Dougall.

(Read November 15, 1866.)

Abstract.

The author described the difference between the southern Silurian and Highland types of scenery as very striking. In the former there were no peaked and rugged mountains, like the Cobbler, but an assemblage of hills from 1500 to 2400 feet high, of various forms—oblong, conical, and dome-shaped—apparently isolated, but all connected, and covered with matted grass from base to summit. Another peculiarity was their uniform smoothness. For miles no tree or shrub appeared. The smooth uniformity of these hills leads to the supposition that they have been acted on by some powerful natural agency; for, smooth as they now appear, great irregularities must have formerly existed; because the strata are all greatly disturbed and nearly vertical. The form of the hills seem to indicate that the operating agent was not aqueous. The village of Wanlockhead is about two miles from the noted Lead-hills, which is perched on the water shed of the Nith and Clyde valleys. Wanlockhead, or Grey Glen, lies at the top of a broad valley, and at the base of a high hill called "the Dod." The Wanlock water flows down the valley and joins the Crank, and both flow into the Nith. The strata of this valley consist of Silurian shale very confused, and dipping at all angles and much changed by heat. It is characteristic of these valleys that they suddenly terminate in corries. In a section of shale dipping west at 25° the *graptolites* exhibited were found. For a space of three miles the valley is covered with the *debris* of mines in operation or exhausted and abandoned. The metallic lodes all run N.E. and S.W., generally at right angles to the enclosing strata, and dipping at 75°. Some of the mines are 140 fathoms deep. The lead

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is found in the state of sulphide. It contains an appreciable quantity of silver, and is called argentiferous galena. It also contains antimony, which is injurious to its quality. The matrix of the ore is calcareous spar, quartz, manganese, and heavy lamellated spar. The galena is usually found in small nuggets, though less seldom in large masses. Other minerals are found with it, such as carbonates, phosphates, arseniates, and vanadiates of lead, with the compounds of iron, zinc, and copper. A lode of chrome iron was said to have been recently discovered, but it has not yet been wrought. An attempt was lately made to find gold by washing some of the detritus, but with less success than by King James' men, if it be true that the *bonnet* pieces presented to the guests at his wedding, were made from gold found in this district. Lead hills is about 1600 feet above the level of the sea, and its climate is consequently cold and bleak. The contour of the hills in the Glengonar valley is striking, and suggestive of the same agent which has smoothed the hills on the Nithsdale side. From Wanlockhead you ascend the Lowthers 2377 feet, from the summit of which may be seen Arran, the Solway Frith, and between them numerous smooth rounded heights, the work of the "old ice sheet," and at your feet the immense deep green valley of the Enterkin. At its deepest part, the Enterkin runs north-east and south-west. The most dangerous part for travellers is its upper portion. The flanks of the Stey-Gail and Thirstane hills enclose the head of the valley. To see the Enterkin, you must go along a footpath on the side of the Stey-Gail at a height of about 300 feet, dipping at an angle of about 60°. Thirstane hill appears steeper than Stey-Gail, and their bases approach each other very closely. The lower part of the pass is very striking. On reaching the lower level at the junction of Ballinton Burn with the Enterkin, the colour of the soil changes, and about 50 yards up the burn, a section is seen of a junction of the New Red Sandstone with the Silurian. This Sandstone is not more than four feet thick, and at an angle of 25°; its position leads to the inference that a great deposit of this formation had at one time stretched over the district underlaid with other strata now all swept away by the agency of ice. Its junction with the Silurian is very marked—gently sloping beds of the New Red Sandstone on the one hand, and the corrugated, glistening, green-coloured Silurian on the other. After citing De Foe's description of the Enterkin, he next

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described the lithological character and origin of the district. The Silurian beds consist of dark, glistening, foliated shales, gritty, arenaceous flagstones, micaceous, close grained, metamorphosed schists, fine conglomerates, and thin beds of argillaceous shales—some of which are highly ferruginous, and more or less altered by heat—nearly vertical and greatly disturbed. There is an apparent absence of intrusive rocks; the conformation of the surrounding hills and the intervening valleys leaves little room to doubt that the former have been divested of an immense thickness of once overlying strata, and the latter scooped out by some powerful agent. The missing strata are now found in the sands, gravels, clays, moraines, and detritus of the neighbourhood, and the denuding agent was doubtless land ice. He stated the two theories of glacial action, giving the preference to the more modern one suggested by Agassiz, which would account for the present conformation of the district of the Enterkin. He considered the Enterkin and the Mennoch valleys as the tracts of a pair of glaciers originating on the Lowthers and terminating in the valley of the Nith.

LXVII.—*On the Occurrence of a Fault in the* Old Red Sandstone *and* Ballagan Series *in Dumbuck Glen, near Dumbarton.* By Mr. John Young.

(Read January 17th, 1867.)

In my paper on the geology of the Campsie district,* when speaking of the existence of the Ballagan series along the western flanks of the Kilpatrick hills, I stated that there were certain sections of these thin bedded limestones to be seen in Auchenreoch and Dumbuck glens, near Dumbarton. At that time I had not visited Dumbuck, but since then I have had several opportunities of inspecting the strata in the lower reaches of the glen. And what I have now to bring under the notice of the Society is, the occurrence of an interesting fault in its Old Red sandstone and limestone strata, by which the two series of beds are thrown up against each other at a highly reversed angle. The glen lies a short distance to the westward of Dumbuck, a conical

* Trans. Geol. Soc. Glasgow, Vol. I., Part I., p. 14.

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hill of trap, composed of great beds of stratified volcanic ash, capped by columnar and amorphous basalt of considerable thickness. The form of this hill is familiar to all those who journey up and down the Clyde by rail or river. The glen is approached by, and lies on the northern side of, the Bonhill Road. At its foot an extensive greenstone dyke, of compact texture and bluish-grey colour, is seen crossing the strata of the old red sandstone in a direction nearly east and west. The greenstone is quarried for macadamising purposes, and the sandstone seen to be considerably changed where it is in contact with the dyke, but its stratification is not otherwise much disturbed. In proceeding for some distance up the glen, beyond the trap dyke, the banks of the stream are low, receding, and covered with wood; but in several small escarpments, strata of soft laminated red sandstone are seen in the banks and bed of the stream, dipping at a low angle towards the Clyde. A little further up, the strata is still seen to be a reddish sandstone, with a few exceptional beds of a yellowish-grey colour, and flaggy structure. About a quarter of a mile from the entrance of the glen, the strata begin to take on a more rapid dip from the hill; and on rounding an angle of the stream, we come suddenly in view of the fault in question in an escarpment on its western bank about thirty feet in height. The strong contrast which is here exemplified between the strata of red laminated sandstone, the thin-bedded, yellowish-grey limestone, and marly shales of the Ballagan series, makes this part of the glen of particular interest to those in quest of geological phenomena.

The line of fault runs from east to west, the sandstone being pushed up at an angle of 20 degrees, with a dip to the south-east. The face of the fault inclines southwards from the perpendicular, and upon it lie, in close contact, the limestone and shales formerly mentioned, at an angle of 45 degrees, but which rapidly become less in dip as we retire from the fault. The downthrow of the Ballagan strata is to the north-east, and the red sandstone, which forms the lower reaches of the glen, is no more seen above the fault. From this point upwards the limestone strata form several interesting sections. At one place, where a felstone dyke crosses the strata, the dip is seen to be changed from north-east to south-east, which is the normal dip of the strata in the glen; while at another point, in an escarpment on the western side of the stream, the limestones are seen to assume an arched form. All the strata

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of this part of the glen seem to dip away under the trap of Dumbuck hill, which, along with the traps of the south-western front of the Kilpatrick range, I believe to be incumbent on strata of the Ballagan series. Dumbuck glen is the only locality where I have seen these beds faulted against the underlying red sandstone. In other localities the one series of beds are seen to rest quite conformable the one on the other. The limestones of this glen present the very same mineralogical features as they do in various localities of the Campsie district. Mr. J. W. Young has shown that they contain a notable percentage of magnesia,* and ought, therefore, to be regarded as impure dolomites, having no doubt been formed by chemical segregation in the strata similar to our nodular clayband ironstones. The strictest search has yet failed to find in these beds the remains of any truly marine organisms, such as corals, crustacea, or mollusca, by which their age might be correctly determined. As stated in my former paper, all the organisms hitherto found consist of a few scattered fish scales in a grey sandstone in Auchenreoch glen, and some Lepidodendroid plants in similar strata at the Spout of Ballagan and the Corrie of Balglass near Fintry. At present it is impossible to state on fossil evidence whether they be of fresh-water or marine origin. It would therefore be very desirable, when visiting localities where they occur, to keep a strict look out for organic remains. This group of strata has been considered by some geologists to be of Upper Old Red Sandstone age; but I have always been inclined to regard them as Lower Carboniferous, and the occurrence, it is stated, of very thin seams of coal in these beds under the traps of the Fintry hills, inclines me still further to this belief.

In closing these remarks, I have only to state further, that strata, similar in character to the Ballagan series, occurs among the hills above Greenock, in the district around Loch Thom. I have never had the opportunity of seeing the beds in that locality, but I am inclined to believe that they are the equivalents of the group of strata north of the Clyde, only in the Greenock hills the limestone bands are not so largely developed as in the Campsie and Levenside districts.

* *Ante* p. 64.

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LXVIII. *Further Observations on the* SURFACE GEOLOGY *of* GLASGOW.

By JAMES BENNIE.

(Read November 15, 1867.)

WHEN it was established that the brick clay of Windmillcroft contained glacial shells, as detailed in a former paper,* the question naturally arose, is this exceptional, or is it an indication that all the brick clays of Glasgow are more or less charged with glacial shells? For the time, no decisive, because no definite answer was possible. It is true that Mr. Smith, of Jordanhill, has recorded in his paper "On the Relative Levels of Sea and Land,"† that he had found six species of shells in a brickyard at Glasgow; but he does not specify them by name, nor does he even indicate where the brickfield was situated—an unfortunate omission, as we cannot take the fact to prove more than that the sea was once here at Glasgow. Had he but named the locality, we might have found other shells there; and been thereby enabled to determine the age and character of the clay in which they occurred. Mr. John Craig, as quoted by Mr. Robert Chambers, ‡ speaks of the sand in which the London Street canoe was found, as "resting upon laminated clays which abound in several places, with recent marine shells;" and that London Street was one of these places is evident from marine shells having been found along with the canoe—a fact I had lately confirmed by a person who remembers of having seen the canoe dug out. Mr. Ferguson, ‖ in addition to his own discovery of shells in sand in Sauchiehall Street, quotes Mr. Craig as having found shells in clay at Annfield, Camlachie—a fact to which I have had independent evidence on two occasions in my enquiries amongst men who had wrought in that brickfield. These are all the instances that I find recorded of shells having been found in the brick clays of Glasgow. They are not many, yet they would have been sufficient to determine whether they were of glacial character or simply marine, if the species had been named even in the imperfect nomenclature of the time; but the discoverers of them having in view only the changes that sea and land had undergone, they unfortunately contented themselves with simply saying that the shells were undoubtedly marine. Happily, however, Mr. Smith, of Jordanhill, placed some of the shells found in the Andersonian Museum, where I had lately an opportunity of

* *Ante* p. 100. † Quart. Journ. Geol. Soc., Vol. 2, p. 427. ‡ Ancient Sea-Margins, p. 206.
‖ Raised Beaches of the Clyde, Proc. Lit. and Phil. Soc. of Liverpool.—Feb 20, 1854.

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examining them. They consist of two species, *Tellina proxima* and *Leda caudata*, and are simply labelled "Glasgow." I remember, when I first saw these shells, of asking the then keeper of the Museum, Mr. Jardine, if he knew the exact place in Glasgow where they were found, and was told they had been got in the foundation of the present Glasgow Bridge, and given by the builders to Mr. Smith. I think this tradition correct, as we know that the clay bed of Windmillcroft extends across the Clyde, from its being frequently disturbed by the dredging machines while deepening the river. Further, the condition of the shells themselves is so completely identical with that of those found in Windmillcroft, that I have now no hesitation, after examination and comparison, in refering them to the same bed and period, even without the tradition.

Having learned from these facts the positive occurrence of glacial shells in certain of our brick clays in Glasgow, and their probable recurrence in them all, I determined early in the past season to let no opportunity of adding to their number pass unimproved; and, for that purpose, watched every excavation in which clay was exposed, and washed many parcels of it, in the hope that that mode of research might succeed where ordinary ones failed. The first clay I experimented upon was from St. Enoch Square. I found nothing in it; but another observer, I am glad to say, succeeded. A small group of *balani* having been found in that locality by Mr. Dairon. The next instance occurred at Port-Eglinton, with clay dug out of the foundation of the bridge that carries the Union Railway across Eglinton Street; and, in the residual sand that remained after washing the clay, I found abundance of Foraminifera and a few valves of Entomostraca. The Foraminifera were very minute, in excellent preservation, and of only one species, *Nonionina striato-punctata*. The depth at which they were most abundant was from eight to ten feet; but from the irregular manner they appeared in the washings, it was clear that these minute life remains are not distributed equally throughout the clay bed at that or any depth, and the probability is that they are confined to patches, or possibly to some single layer. As no remains of mollusca appeared in connection with these Foraminifera, we may safely conclude that none existed in the clay at Port-Eglinton as far down as the excavations extended—a depth of ten feet—an absence which warrants the inference that, during the long lapse of time requisite for the deposition of so much sediment, no higher

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life than that possessed by these humble forms lived in the water, from which it was precipitated—a fact worthy of notice, as significant of the conditions of the sea at the period it represents.

Encouraged by this casual discovery, I went to the nearest clayfield—that of Muirhouses, situated at the head of Eglinton Street, and subjected the clay there to the same mode of examination, and was rewarded with even greater results. The clay-bed is here very deep, forty feet being occasionally wrought at; but there are few, if any, life remains found lower down than half that depth, and they are decidedly most frequently met with eight to fourteen feet from the surface. They consist of two species of Foraminifera—*Nonionina striato-punctata* and *Quinqueloculina seminulum*—four or five species of Entomostraca, a young specimen of *Cyprina Islandica*, and occasional groups of *Mytilus edulis*. The mollusca are very rare, the Entomostraca numerous in certain layers, while the Foraminifera are so extraordinarily abundant in some parts, that half of the residuum frequently consisted of them alone. The Foramenifera are always in excellent condition—as perfect apparently as in life, glittering amongst the grey sand like diamond dust undimmed either by abrasion or corrosion. The Entomostraca were generally whitened by corrosion—a result of the clay where they occurred being more open, from a greater admixture of sand. I may state—as it may give a better conception of the conditions under which the clay was deposited—that in the lower part of the bed, the clay is so pure that only a pinch or two of sand remains after washing several pounds of it; in the upper part, where the shells occur, the sand increases as we come upwards, till the clay disappears altogether; and the uppermost layer in the section is composed only of sand, in which no remains of marine life have as yet been detected, nor is it likely that any will ever be found, as it is probable, from a layer of peaty matter that runs through the middle of this sand-bed, that fresh water conditions alone prevailed while it was deposited.

The next clayfield in which I succeeded in finding traces of life, was that of Polmadie, situated immediately to the east of Govan Malleable Iron Works. The clay here is very pure, finely laminated, and remarkably free from sand, grit, or stones. As at Muirhouses, the lower parts of the clay-bed seem to be, if not absolutely azoic, so nearly so, that though I attempted several times to find remains of life in clay taken from the depth of

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twenty-five, twenty, and seventeen feet from the surface, I did not succeed in finding any, and it was only in clay from above seventeen and below seven feet, that I at length found a considerable number of Foraminifera of the species *Nonionina striato-punctata*. In size and condition they resemble so exactly those from Muirhouses, that we may safely conclude that they lived at the same period, and under similar circumstances; and that the great bed of clay which stretches from Pollokshields to Polmadie has scattered through it—irregularly in patches, or continuously in layers—remains of marine life sufficient to prove it to be, not merely a deposit from ordinary sea-water, but from a sea in which glacial conditions to some extent prevailed.

Of the other parts of the Glasgow clayfield, stretching from Windmillcroft across the Clyde to St. Enoch Square, and from thence through the city, underneath the sands and gravels of the river-drift, to Camlachie, where it comes to the surface and culminates in beds sixty feet deep, I cannot from my own researches report so favourably as, with the exception of a few Foraminifera which I found in clay taken from under twenty feet of river-drift, at an excavation for a water pond to Fordneuk Mill at Crownpoint, the general residuum was a little grey or red sand with nothing in it. I experimented with clay from all the various clayfields of Camlachie, from Annfield in the Gallowgate to Newlands in the London Road, and if remains of life had been diffused through the clay of these fields as at Muirhouses or Polmadie, I must have lighted upon traces of them; and since I did not do so, we must revert to the instances already alluded to of shells having been found in St. Enoch Square, London Street, and at Annfield, to prove that the north side of the Glasgow clay-bed is n character analogous, and has had an origin identical with that of the south side. This conclusion is confirmed by the fact—of which I have recently seen many proofs—that an underground connection exists between them, clay having cropped up in so many excavations made lately in the river-drift occupying the centre of the intervening space, that there can be no doubt that clay under-runs it all from side to side, and were the drift removed, we would see the clay extending uninterruptedly from Pollokshields to Camlachie, and be convinced that the whole bed was one in formation and period, and that the difference that obtains between each locality as regards shells, is no more than the distance between them renders probable.

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Such are the results of my researches during the past season among our Glasgow brick clays. Though not of great moment, yet the knowledge they give us of the general character of these clays, fully repays the labour in making and recording them. Combining what we have learned from them with what the clay of Windmillcroft taught us last year, we infer that the great bulk of our brick clays are not azoic, as formerly supposed, but have diffused through it the remains of about twenty species of mollusca, or other humbler forms of life—that from the character of some of these shells, the sea they lived in was glacial in its conditions, and was, probably coëval with that which forms the great shell-bed of Paisley; but why the same sea should be so rich in life there and so poor here, is more than I can determine, unless—as the great thickness of clay of Polmadie, with only one form of life in it, indicates—I conclude that the great outburst of life in the glacial sea had not yet taken place, or had long gone by, when our brick clays were formed; but in that case we ought to have a boreal shell-bed in Glasgow, equivalent in life and time to that of Paisley, either above or below those beds at Muirhouses and other places where shells now occur, and it is strange, if such there be, that it has not yet been fallen in with. I have sometimes thought that as there is evidence that our clay-bed has undergone much denudation, either before or during the river-drift period, that this supposed shell-bed may have perished then, and that so completely, that very few vestiges of it remain to reward discovery. To show that there is warrant for such a thought, I may state that, in answer to inquiries made at the workmen in the clayfields, as to whether they ever found shells in the clay while working it, I have learned that shells of various species were found in making the Paisley railway at Bellahouston, at a depth of sixteen feet; in a clayfield situated in what is now Victoria Street, Govan, at about the same depth; in the Shields clayfield at fourteen feet; in the excavations for the new gasometers at the Gorbals gas works at eight feet; in Lilybank clayfields at sixteen feet; at Polmadie clayfield at twenty-seven feet; and Mr. Smith, of Jordanhill, records that the workmen in the Glasgow clayfields often told him that they were not deep enough for shells, meaning thereby, as he explains, that though they found few shells at the depth at which they ordinarily wrought, yet when they went deeper, in digging wells or drains, they came frequently upon them. Whether facts like these war-

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rant my thought or not, they at least show that discovery has not yet exhausted the Glasgow brick clays, and that industry in research, even in them, will not go unrewarded.

In my former paper, while speaking of the thickness of the clay and white sand exposed in Windmillcroft, I could only use indefinite terms, because, in the circumstances, an approximate estimate was all that was possible; but through the kindness of Messrs. Wm. Holms & Brothers in furnishing a copy of the "Journal of a Bore for an Artesian Well," made in their works at MacPhail Street, Greenhead, I can now give exact measurements of the strata which constituted, at that point, the surface geology of the district.

Forced surface,	5 ft. 0 in.		
Coarse sand,	1 ,, 6 ,,	River Drift,	11 ft. 0 in.
Clay mixed with sand,	2 ,, 0 ,,		
Coarse sand,	2 ,, 6 ,,		
Good clay,	8 ,, 0 ,,	Marine Clay,	38 ,, 0 ,,
Muddy clay,	30 ,, 0 ,,		
Soft running sand with gravel,	51 ,, 0 ,,		
Whinstone block,	2 ,, 4 ,,	White sand series, probably marine,	61 ,, 9½ ,,
Sand and gravel,	7 ,, 0 ,,		
Sandstone block,	0 ,, 5½ ,,		
Sand and gravel,	1 ,, 0 ,,		
	110 ft. 9½ in.		110 ft. 9½ in.

Of the old river-drift I have little new to report. Several excavations have been made in it during the past season, but nothing very remarkable was elicited. The largest was for a water pond for Fordneuk Mill, Mile-end, and shewed in section 20 feet of sand and gravel, overlaying clay and white sand as at Windmillcroft, but there was no collection of vegetable *debris*, nor any leaf-beds to make the resemblance complete. A patch of peat-like debris, overlaid by two or three feet of yellow clay, occurred in one corner of the excavation, shewing that it had once been a sub-ærial surface upon which moss grew, and that afterwards it had been overflowed by the water which deposited the clay. At the foot of the gravel-bed several layers of clay balls occurred, which had evidently been once portions of some adjoining clay-bed upon which the currents of the old river had acted, tearing it into pieces, and then moulding the pieces into well rounded peebles of clay. They were so like the marbles which our recent boys use in their games, that I at first thought I had stumbled upon the workshop of the pre-historic worker in clay, who made the marbles,

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that the children of the canoemen played with. The excavation of Windmillcroft has been completed, but nothing of further interest was revealed, as the different beds exhibited the same characters, and the same relationships to each other as before. Among the last things turned out, however, was the best specimen of those perforated stones I have called "sinkers" that has yet been found, and which, I humbly think, places my determination of their use and character beyond doubt. It is flat, sub-triangular, well-rounded at the edges, and in composition is a trappean felstone. The perforation is situated near the apex, and has been driven first from the one side and then from the other. The edges of the perforation have been neatly bevelled. Its weight is twenty-two ounces. Mr. Fraser Christie has found another sinker at the same place (one of the bends of the river at West Thorn) where he found the first one, so like it in size, shape, weight, and composition, that he fancied that they had both been made by the same man, at the same time, from the same stone.

Such has been the work of the past season. It has not advanced our knowledge much; still it has not been altogether in vain, as it has shewn that the hasty conclusion that our upper brick clays were devoid of life is incorrect, and enables us to understand better than heretofore the earlier or the latter times of the period which the great glacial shell bed represents. If we accept as a rule that height indicates age invariably, we might conclude, without hesitation, that, as the height of Muirhouses (fifty-seven feet) is double that of Paisley (twenty-eight feet), the exceedingly rudimental life of Muirhouses preceded that of Paisley, were it not that our knowledge is at present too confused to justify such a conclusion, and it is, therefore, preferable to wait till discovery makes it certain ere we adopt it finally. In the meantime the search for data should be continued and extended, and greater heed taken of every chance exposure of shells that occur.

LXIX. *On some points in the* SURFACE GEOLOGY *of the* SOUTHERN HIGHLANDS. By Dr. JOHN YOUNG, *President.*

(Read December 6, 1867.)

ABSTRACT.

AFTER a brief recapitulation of the geological features of the great Lower Silurian tract known as the Southern Highlands, and of the

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relations of the younger palæozoic rocks to its northern border, that is along a line stretching from Girvan to St. Abb's Head, and to its southern limit, that is a sinuous line from Eyemouth to the mouth of the river Nith, Dr. Young described the general aspect of the scenery between these two approximately parallel lines, and mentioned the local exceptions to its prevailing character.

The points discussed were, the probable periods at which this great Silurian tract had been subjected to denudation, and during which the two systems of drainage, which Mr. Geikie, in his work on the "Scenery and Geology of Scotland," has termed "longitudinal" and "transverse." The rock terraces, sometimes spoken of as old beaches, but which were in reality due to erosion by ice, were referred to. The deposits described were—1st, Boulder Clay—*(a)* unstratified, *(b)* stratified; 2nd, The glacier moraines in the Loch Skene and Loch Doon districts; 3rd, The surface wash of the Lammermuir and Peeblesshire hills; 4th, The sands and gravels bordering the district; 5th, The older and newer river alluvium; 6th, The peat mosses, with special reference to Mr. J. Geikie's paper in the "Transactions of the Royal Society of Edinburgh." A comparison was drawn between the heights to which the moraine-bearing glaciers in the Northern and Southern Highlands have descended, and the difficulty in explaining this difference was pointed out. In conclusion, Dr. Young referred to the upper limit of the sand and gravel series so far as it had been determined, on the east and west sides of Scotland; and taking into consideration the character of the fossils found in the glacial clays in these two regions, suggested that the elevation of the country during the latest period of the glacial epoch might have presented differences parallel to those found to have existed during the earlier carboniferous period.

LXX. *The* Post-Tertiary Fossiliferous Beds *of* Scotland. By Rev. Henry W. Crosskey, *Vice-President* Geol. Soc. Glas., and Mr. David Robertson.

Introduction.—In the series of papers which we propose to communicate to the Geological Society of Glasgow, we shall endeavour to describe the Post-Tertiary fossiliferous beds of Scotland, according to the plan adopted by Dr. Michael Sars for the

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corresponding beds of Norway in his monograph—"Om de i Norge Forekommende Fossle Dyrelevninger fra Qvartærperioden."*

Separate lists will be given for each locality, recording the proportions which the species already observed bear to each other, as well as the fact of their occurrence. This work is essential for the correct classification of the various beds, and will provide the material from which theoretical geology can draw its own conclusions.

It is important to distinguish the beds of the glacial epoch from each other, as well as from those belonging to succeeding periods. The various glacial clays and sands may indicate different depths and conditions of sea-bottom, as well as, possibly, variations in intensity of cold—correct observations of which are of the utmost importance, (1), for their correlation with the beds of other countries; (2), the solution of problems connected with distribution of species; (3), and the determination of those physical changes accompanying the gradual amelioration of climate.

It is impossible, also, for any accurate student to gather into one undiscriminating list the fauna of the beds succeeding the glacial epoch. Their contents, in connection with their elevations, must be examined separately in order that it may be determined, (1), whether intervals of subsidence have broken the last great movement of upheaval; and (2), whether the climate has changed by regular and steady degrees, or has at all fluctuated from colder to warmer and back to somewhat colder again.

All the deeper problems, indeed, connected with the last changes in the physical geography of the country, have their difficulties multiplied, so long as the two usual lists of the fauna immediately connected with them alone are given—one being termed "glacial," and the other "raised beach"—since beds may be classed together under these general terms separated almost by the breadth of an epoch.

We are quite aware that all lists which the most industrious students can elaborate are necessarily more or less temporary. A species may be rare at one part of a clay pit, and within 100 yards or less, and in precisely the same clay, be abundant and characteristic; so that a fresh excavation may give a new aspect to the apparent grouping of the various forms. Exactly the same method of distribution prevails with these fossils from Post-

* Christiania, 1865, 4to, 4 plates.

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Tertiary beds, as with the inhabitants of the sea-bottom of the present day. Different species have their peculiar individualities of habitat often within very short distances of each other. *Solen ensis*, e.g., is plentiful round Cumbrae in all the banks of muddy sand, but upon one bank, *S. siliqua* occurs, and there scarcely an example of *S. ensis* has yet been found, although the banks are as nearly as possible similar in composition and not a quarter of a mile from each other. In the same way, *Pecten Islandicus* is abundant in the glacial clay in one locality, and will be replaced in the immediate neighbourhood by a different characteristic shell.

Cytheridea punctillata (to give another example)—an abundant fossil form—is plentiful living in Loch Fyne, but rare in every other part of the west coast.

The collector of glacial fossils is thus exactly in the position of the marine naturalist—he has to deal with an elevated sea-bottom in which many forms had their own especial dwelling-places.

The difficulty in the way of making satisfactory catalogues is, moreover, increased by the position of the shell-beds. In very few instances can the shell-beds be found in section, and they generally have to be reached through incidental excavations. Sometimes, also, especially along the great line of those deposits occurring at half-tide, the older and the younger sands and clays are in such close proximity that their contents are in grave danger of becoming intermingled. With such constantly fluctuating opportunities for examination, and liabilities of error, it is of the highest importance that the work of examining and separately recording the fauna of every separate deposit should be regularly and carefully carried on.

We shall adopt throughout these papers, with regard to the mollusca, the nomenclature accepted by Mr. J. Gwyn Jeffreys in his work on British Conchology.*

The promiscuous employment of the many synonyms possessed by a large proportion of the species with which we are concerned, has led to such confusion, that the adoption of some uniform system has become absolutely necessary; while the value and accessibility of Mr. Jeffreys' work render it, we would submit, desirable that the nomenclature his authority has sanctioned

* British Conchology. By John Gwyn Jeffreys, F.R.S., F.G.S. London: J. Van Voorst, 1862-7.

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should come into general use among the students of Post-Tertiary Geology.

Some shells well known to Scotch geologists, will appear under unfamiliar names; for example—

Nucula oblonga, Brown.	=	*Leda pernula*, Müller.	Jeffr. ii. p. 157.
Tellina proxima, Brown.	=	*T. calcarea*, Chemnitz.	Ibid. ii. p. 389
Trophon clathratus, F. & H.	=	*T. truncatus*, Ström.	Ibid. iv. p. 319.
Fusus scalariformis, Gould.	=	*Trophon clathratus*, Linn.	Ibid. iv. p. 321.
Natica clausa, B. & S.	=	*N. affinis*, Gmelin.	Ibid. iv. p. 229.

In the species figured in Sir C. Lyell's Elements, 6th ed., p. 153, therefore, according to this system, Fig, 130 is Leda pernula, *not* L. oblonga; Fig. 133 is Natica affinis, *not* N. clausa.

In the same plate, it may be noted, in passing, that Fig. 129, *Astarte borealis*, is an accidental mistake for *A. compressa*.

The advantage of systematic reference to one standard work will however, we believe, amply compensate for a merely temporary unfamiliarity.

We have to acknowledge our very great obligations to Mr. Jeffreys, who has personally examined the larger part of our collections, and thus given to our lists of mollusca a value they could not otherwise have possessed. We have also to thank Mr. H. Brady for his kind assistance in determining the Foraminifera, and the Revs. A. M. Norman and Thomas Hincks for their aid in the examination of the Polyzoa.

I.—DALMUIR.

The deposit at Dalmuir was first described by Dr. Thomas Thomson in a paper entitled, "On a deposit of recent marine shells at Dalmuir, Dumbartonshire," and published in the Records of General Science, vol. i., p. 133, 1835. It appears that the proprietor of the district had found it convenient to alter the course of the Dalmuir burn, about 8½ miles from Glasgow. During the formation of the new course, a great deal of sand was cut away, and the workmen came upon a mass of shells. Dr. Thomson described the locality as follows:—

"The locality in which the fossils are exposed is situated on the banks of the Dalmuir burn, about 100 yards above the bridge by which the road from Glasgow to Dumbarton crosses it, and about a mile from the Clyde. The current of the stream is not very rapid, so that the bed of shells is probably not more than 20 feet

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above the level of the Clyde, which, at that place, is sensibly salt at high water. The breadth of the channel of the stream at this place is about 14 feet, and the depth of the banks is about 2½ feet.

"The sandy deposit appears to extend on both sides of the stream, upwards and downwards, without alteration; but the fossils are confined to a circular or rather elliptical face, the breadth of which (across the stream) is about 25 feet, while its length is only about 15 feet.

"The deposit extends back from each bank only about 6 feet, so that more than one half the whole mass has been cut away during the change of the course of the rivulet. The whole depth of the bed as it exists at present is about 2½ feet; but I am informed by the overseer upon the estate who superintended the workmen during their operations, that after the soil had been removed, ten or twelve feet of earth full of sand was carried away, so that the depth of the bed in its original state must have been 12 or 14 feet."

Dr. Thomson collected 31 species, and expresses his acknowledgments to Mr. G. B. Sowerby for his assistance in determining their names.

We subjoin the list with notes regarding the probable identification of some of the species:—

Species. Dr. Thomson's List.	Species to which Dr. Thomson's may be referred.	Notes.
Echinus esculentus.		Probably an error for *E. Drö-bakiensis*, Müller, which is abundant.
Balanus costatus.		
Mya truncata.		"Only one imperfect specimen has been found," observes Dr. Thomson. We find the young abundant, although adult forms are exceedingly rare and fragmentary.
Amphidesma Boysii.	Scrobicularia alba. *Wood.*	
Saxicava rugosa.		
Tellina tenuis.		It is curious this should be the only *Tellina* mentioned, although *T. calcarea* is common.

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Species. Dr. Thomson's List.	Species to which Dr. Thomson's may be referred.	Notes.
Lucina flexuosa.	Axinus flexuosus, *Mont.*	
Cyprina vulgaris.	Cyprina Islandica, *Linn.*	
Cardium edule.		Described as "extremely scarce." It is the same in our collections.
Nucula minuta.	Leda pernula, *Münster.*	Probably. See Jeffreys' Brit. Con., ii., p. 157.
Astarte minima.	Astarte compressa. *Montagu.*	Probably—since *A. compressa* is the only abundant *Astarte*, and the species is said to be "very common."
Anomia ephippium.		
Mytilus edulis.		
Modiola albicostata.	Modiolaria discors, *Linn.* Var. lævigata. *Gray.*	Possibly; we find the young of that species.
Pecten Islandicus.		"Very common."—Thomson.
——— *pusio.*		
Lottia parva.	Tectura virginea, *Müller.*	"Very common."—Thomson.
Fissurella Noachina.		"Very common."—Thomson.
Helix lævigata / *Velutina communis.*	Velutina lævigata, *Penn.*	See Jeffreys' Brit. Con., iv., p. 242. The *H. lævigata* of Linn. appears to be a lost species. (Jeffreys') and the two names given by Thomson may be probably referred to *V. lævigata* of Pennant. If two species of *Velutina* were found, the second would in all likelihood be *V. zonata* (Gould)—*V. undata* (Smith), which occurs at Dalmuir.
Natica glaucinoides.	Natica affinis, *Gmelin.*	There is little doubt of this identification, since the so-called *N. glaucinoides* is said to be very common, and *N. affinis* is the characteristic *Natica* at Dalmuir.
Littorina vulgaris.	Littorina littorea, *Linn.*	
Trochus cinerarius.		

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Species. Dr. Thomson's List.	Species to which Dr. Thomson's may be referred.	Species.
Margarita ——— ?	Trochus ——— ?	
Rissoa ——— ?		
Lacuna vincta.	Lacuna divaricata. *Fabr.*	"Very common."—Thomson.
Fusus Bamffius.	Trophon truncatus. *Ström.*	"Very common."—Thomson.
—— *lamellosus*	Trophon clathratus. *Linn.* Var. Gunneri *Löven.*	
Buccinum undatum.		
———*striatum.* n.s.?	B. Grœnlandicum, *Chem.*	This was described and named by Sowerby as a new species. It is referable, however, to *B. Grœnlandicum*, Chemnitz. The full description is given (Records of General Science, I. p. 136) so that there is no doubt of this identification.

Dr. Thomson makes a special note of the fact that *Ostrea edulis* has never been met with at Dalmuir. We have, as yet, equally failed to discover it, either at Dalmuir or in any of the older glacial clays of the Clyde district.

The description given by Dr. Thomson attracted the attention of Mr. James Smith.* Mr. Sowerby had pronounced three of the species to differ from any known recent British shells. One of them was said to be *Natica glaucinoides*, a Crag fossil (really, we believe, *N. affinis*, described as *N. clausa* by Searles Wood in monograph of Crag mollusca, part I., p. 147); another was called *Fusus lamellosus*, "which had only been observed about the straits of Magellan" (a mistake for the arctic species now called *Trophon clathratus*, var. Gunneri), and a third, *Buccinum striatum*, "an unknown species" (now identified with *B. Grœnlandicum*, Chemnitz.) The fact, however, that these species were unknown as British, led Mr. Smith to imagine that the term "recent," which had been usually applied to such deposits, was not rigidly correct; and in order to ascertain this point, he determined to collect as many of the shells as he could, and made a fresh excavation at Dalmuir.

* Memoirs of Wernerian Society, vol. viii., part 1, p. 50.

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Mr. Smith states that he increased the number of species from that locality to "upwards of seventy;" the following catalogue, however, contains all to which he has specially affixed "Dalmuir" in his "Catalogue of Shells from the Glacial Deposits of Britain and Ireland.*

After striking out one or two cases in which the same shell appears under different names, the number of species from Dalmuir which Mr. Smith has left on record amounts to forty-five; and there is no possibility of ascertaining what the other species he collected actually were.

Species In Mr. Smith's Catalogue.	Species to which Mr. Smith's may be referred.	Notes.
Abra alba.	Scrobicularia alba. *Wood.*	
Aporrhäis pes-pelecani.		
Artemis lincta.	Venus lincta, *Pulteney.*	
Astarte crebricostata.		
——— *multicostata.*	A. compressa. *Montagu.* Var. striata. *Müller.*	
——— *Uddevallensis.*	A. compressa var.	"It agrees with the shell figured in Lyell's Uddevalla fossils, f. 21, 22, and named by me accordingly."—(Smith.) The Uddevalla form referred to is, however, *C. compressa.* See list of Uddevalla Fossils in Jeffreys' Report, 1863. (British Association for adv. of Science.)
Balanus balanoides.		
——— *costatus.*		
——— *crenatus.*		
Buccinum striatum.	B. Grœnlandicum. *Chemnitz.*	
——— *undatum.*		
Cardium exiguum.		
Cemoria Noachina.	Puncturella Noachina. *Linn.*	
Fusus antiquus.		

* Researches in Newer Pliocene Geology, p. 47.

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Species In Mr. Smith's Catalogue.	Species to which Mr. Smith's may be referred.	Notes.
Fusus discrepans.	Pleurotoma turricula. *Montagu.*	
—— *imbricatus*, Smith.	Trophon clathratus. *Linn.* Var. Gunneri. *Löven.*	
—— *scalariformis.*	Trophon clathratus. *Linn.*	
Lacuna vincta.	Lacuna divaricata, *Fabr.*	
Leda caudata —— *minuta*	Leda pernula, *Münster.*	
Littorina littorea.		
———— *patula.*	Littorina rudis var. *Maton.*	
Lottia virginea.	Tectura virginea. *Müll.*	
Lucina flexuosa.	Axinus flexuosus. *Mont.*	
Mactra striata.	Mactra subtruncata. *Da Costa.* Var. striata. *Brown.*	
Margarita undulata.	Trochus Grœnlandicus. *Chemnitz.*	
Modiola albicostata, Sow.	Modiolaria discors. var. *Linn.*	The shell referred to in Dr. Thomson's list.
——— *modiolus.*	Mytilus modiolus, *Linn.*	
Murex erinaceus.		
Mya truncata.		
Nassa incrassata.		
Natica clausa	Natica affinis, *Gmelin.*	
——— *fragilis*, Smith.		This specimen was much decayed, so that it was impossible to decide the species.
Nautilus Beccarii	Rotalina Beccarii.	
Nucula minuta	Leda pygmæa, *Münster.*	Previously catalogued as *L. minuta.* The species of *Leda* mentioned by Smith, however, were probably different, although given under synonymns, which strictly refer to only one shell. They were most likely the same as those in our catalogue, viz., *L. pernula* and *L. pygmæa.*

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Species In Mr. Smith's Catalogue.	Species to which Mr. Smith's may be referred.	Notes.
Patella lævis.	Helcion pellucidum, var *Linn.*	
——— *pellucida.*		
Pecten Islandicus		
——— *sinuosus.*	Pecten pusio, *Linn.*	
——— *varius.*		
Pleurotoma discrepans.	Pleurotoma turricula. *Montagu.*	Previously catalogued as *Fusus discrepans.* Both these names refer to same species.
——— *turricula.*		
Rissoa subumbilicata	Hydrobia ulvæ. *Penn.*	
——— *ulvæ.*		
——— *ventrosa.*		
Saxicava pholadis	Saxicava rugosa. var. *Linn.*	
Serpula triquetra		
Tellina Baltica		
Velutina lævigata		
——— *undata*, Smith.	V. zonata. *Gould*	

No further examination of the Dalmuir beds was carried on until, under the direction of Mr. Smith, we turned our attention to them, and made an excavation in the east side of the stream to the north of the bridge on the Dumbarton Road, in the immediately adjacent field, about half-way down. At this point the shells are discovered in great abundance, in the position described by Dr. Thomson, beneath an overlying bed of sand and gravel. Of 11 lbs. of the dry clay from this bed, 3 lb. 2 oz. were lost in washing through a sieve of 96 cross threads to the inch, leaving 7 lb. 14 oz. of a residue. Three-and-a-half pounds of this residue were retained in a sieve of $\frac{1}{8}$-inch mesh, and consisted chiefly of small stones of trap, quartz, and sandstone; a few were quite smooth; many only rounded at the corners; others less or more irregular. Many of the polished stones were fractured and some few finely striated. The bulk of the shelly debris in this portion was made up of *Mytilus edulis* and *M. modiolus.* The other portion of the

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residue (4 lbs. 6 oz.) consisted chiefly of sand, mixed with the plates and spines of echini, starfish, small shells, etc. One remarkable peculiarity of an echinus of this bed is that many of the spines are knobbed, others fluted, or fluted and flattened.

Besides this north patch of shell-bearing clay, there is another bed a few hundred yards to the south, on the other side of the high road, first pointed out to us by Mr. James Bennie. This section was laid open many years ago by a cutting for the water course of the Dalmuir Paper Mill. The shells are exposed in the bank on the north side of the water course, about forty yards east of Dalmuir Burn. The shell-bearing clay rises about four feet above the water course, when it is overlaid by two feet of water-worn gravel. The upper portion of the shell-bearing clay is more sandy than the lower, which contains more stones, most of them water-worn, some rounded at the corners, a few angular, and a few with well-marked striations. In composition they are similar to those in the north bed.

Beneath the upper clay is a bed of sand (to which Mr. Nasmyth first drew our attention) about six inches in thickness. In this sand the shells occur in the finest state of preservation, and many of the peculiarly arctic forms are especially large and strong. *Trophon clathratus* is, *e.g.*, very abundant, while scarce in the upper part of the clay.

This sand is followed by the stiff, hard, blue boulder clay, in which no shells occur. The complete section is therefore as follows :—

1. Sand and gravel.
2. Shell-bearing clay, about 2 feet.
   a. At upper part mixed with sand.
   b. At lower part not sandy.
3. Sand—Shell-bearing, about 6 inches.
4. Boulder clay, not pierced through.

Here, as at the north bed, the deposit of shell-bearing clay appears very circumscribed. We could not trace it for more than twenty yards along the side of the water course; and from the point where the shells are exposed, the overlying gravel deepens on both sides, east and west.

Although the fauna of the two beds is of precisely the same general character, there are local differences equivalent to those

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which occur in neighbouring parts of the same sea-bottom at the present day.

Tellina calcarea and *Trophon clathratus*, var. Gunneri, are more common than in the north bed; but *Trophon truncatus* and *Lacuna divaricata*, and spines of Echini are much less frequent. The *Mytilus edulis* and *M. modiolus* of both beds are of large size; but neither the *Pecten Islandicus* nor *Cyprina Islandica* seem to have attained the same dimensions as in other glacial deposits of the Clyde district.

We subjoin a catalogue of the species which we have ourselves collected from the Dalmuir Beds.

In subjoining, in some instances, the precise number of specimens we have detected, we do not in any way assume that none have been discovered by others who have examined the beds, but simply intend to indicate the proportion in which they will probably be found in any general collection made upon the same scale as our own. A few shells were collected off the banks; but all the species in the subjoined list were found in about 58 lbs. of the clay, washed and carefully examined.

In this catalogue,

Rare means - - -	1 specimen only.
Rather rare means - -	2 to 5 specimens.
Moderately rare means -	5 to 10 „
Moderately common means	10 to 25 „
Common means - -	25 and upwards.

CONCHIFERA.

Anomia ephippium, Linn.	Common; small.
——— var. *aculeata*.	Rare.
Pecten Islandicus, Müller.	Common; largest specimens only about half the size of those from Kyles of Bute. Up to this point all stages of growth from the fry. Colour of young shells well preserved. Some valves from the lower sand as fresh in appearance as recent specimens.
Mytilus edulis, Linn.	Common; large, narrow, and elongated. Valves united.
——— *modiolus*, Linn.	Common; large size. Valves united.
Modiolaria discors, Linn. var. *lævigata*, *Gray*.	Rather rare. Three single valves of fry only found.

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Leda pernula, Müller	Common; moderate size; several tolerably large, but not equal to the specimens from lower Paisley clay; valves united in several instances; all stages of growth; largest in the lower sand.
Leda pygmæa, Münster.	Common; good average size; fry and full grown specimens.
Montacuta bidentata, Montagu.	Rather rare; two specimens of fry only.
Axinus flexuosus, Montagu.	Moderately common.
Cardium edule, Linn.	Rather rare in upper bed; two fragments of large shells. Rather common in lower sand; ten specimens.
Cyprina Islandica, Linn.	Common; remarkably small in size compared with specimens from other glacial beds. Valves united.
Astarte compressa, Montagu.	Common; full grown specimen and fry.
—— *borealis*, Chemnitz. *sulcata*, Da Costa.	Rather rare; three specimens of fry.
—— var. *elliptica*, Brown.	Rare; one young valve.
Tellina calcarea, Chemnitz.	Common; remarkably small and delicate.
—— *squalida*, Pulteney. *T. incarnata*, Forbes & Hanley.	Two valves only. These specimens were found by Mr Nasmyth, who assures us there can be no mistake regarding their actual occurrence in the lower sand. The appearance of the species in this bed is most remarkable, since (Jeffrey's Brit. Conch. II. p. 385) it does not appear to have been found in the North of Europe, and has a southern range to the Ægean and Azores. We have found it fossil in one of the post glacial beds in Kyles of Bute.
Mactra subtruncata, Da Costa. var. *striata*, Brown.	Rather rare in the upper part of clay; two single valves; common in the lower sands.
Scrobicularia alba, Wood.	Moderately common; ten valves found.
Mya truncata, Linn.	Fry and very young specimens only; common; one fragment and one perfect valve of adult. Thin and delicate like the form described by Sars from the fossil beds near Skien, Norway.
—— var. *Uddevallensis*.	One valve in lower sand.
Saxicava rugosa, Linn.	Common; moderately large.
Saxciava rugosa. Var. *arctica*. *Mya arctica*, Linn.	Moderately common.

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GASTEROPODA.

Chiton ruber, Linn.	Rare; one plate.
—— *marmoreus*, Fabr.	Plates; common.
Halcion pellucidum, Linn.	Rare; one specimen of fry.
Tectura virginea, Müller.	Common; large and strong.
Puncturella Noachina, Linn.	Common; all stages of growth; large and strong.
Trochus helicinus, Fabricius.	Rather rare; fry only; three specimens.
——— *Grœnlandicus*, Chemn.	Moderately common; ten specimens.
Lacuna divaricata, Fabricius.	Common; in such extreme abundance in one part of the bed as to be a characteristic shell.
—— var. *quadrifasciata*. Mont. *Turbo quadrifasciata* Mont.	Moderately common
——— *puteolus*, Turton.	Moderately rare; five specimens.
——— *pallidula*, Da Costa.	Rare; one young specimen.
——— var. *neritoidea*, Gould.	Rather rare; fry only.
Littorina obtusata, Linn.	Common; chiefly young.
– - - - - *rudis*, Maton.	Common; chiefly young.
— ——— *littorea*, Linn.	Common; chiefly young.
——— *limata*, Löven.	Young, common; three adult shells.
Rissoa parva, Da Costa.	
var. *interrupta*. *Turbo interruptus*. Adams.	Common.
Rissoa striata, Adams.	Common.
Skenea planorbis, Fabricius.	Common.
Homalogyra atomus, Philippi.	Common.
Odostomia spiralis, Montagu.	Rather rare; two young specimens.
Natica affinis, Gmelin.	Common; but moderate in size in the upper bed; large and fine in lower sand.
——— *pallida*, Brod. & Sow.	Moderately common; but very large and fine in lower sand.
Velutina lævigata, Pennant.	Moderately common; 15 specimens.
—— —— *undata*, Smith. *V. zonata*, Gould.	Moderately rare; three broken and two whole specimens, large and fine.

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Purpura lapillus, Linn.	Rather rare; two specimens of fry.
Buccinum undatum, Linn.	Common; small and young.
Trophon truncatus, Ström.	Common: large and fine specimens.
——— *clathratus*, Linn.	Moderately rare in upper bed; four large specimens; common and very large in lower sand.
——— — var. *Gunneri*, Löven.	Moderately common; 19 specimens in upper bed; common and very large in lower sand.
Fusus gracilis, Da Costa.	Rare; one specimen of fry only.
Pleurotoma violacea, Migh. & Ad.	Moderately common; 21 specimens.
——— *pyramidalis*, Ström.	Rare; one broken specimen.
Cylichna alba, Brown.	Rare; two specimens.
——— *obstricta*, Gould.	Rather rare; one specimen, large and fine; two small ones.
Utriculus mammillatus, Phil.	Rare; one specimen.
——— *hyalinus*, Turton.	Moderately rare; six specimens.

POLYZOA.

Tubulipora serpens, Linn.

——— *flabellaris*, Fabricius.

——— *hispida*, Fleming.

——— *phalangea*, Couch.

Lepralia verrucosa, Esper.

——— *unicornis* (with central mucro preserved), Fleming.

——— *Peachii*, Johnston.

——— *pertusa*, Esper.

Membranipora unicornis, Fleming.

Alecto —— ? Lamouroux.

Hippothoa catenularia, Jamieson.

Crisia eburnea, Linn.

Discoporella Grignoniensis, Busk. A crag fossil; fine specimens.

(With several other species as yet undetermined.)

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CRUSTACEA.

Balanus porcatus, Da Costa.	Common.
Verruca Strömia, Müller.	Common.
Pagurus Bernhardus, Linn.	Fragments common.

[Many species of Entomostraca also occur, a catalogue of which will be subsequently given.]

ANNELIDA.

Serpula spirorbis, Linn.	Common.
——— *vermicularis*, Ellis.	Common.

ECHINODERMATA.

Echinus Dröbachiensis, Müller.	Common.
Ophiocoma bellis (spines and plates), Link.	Forbes states that this *Ophiocoma* was first figured by Link, who received his specimen from Greenland. It was afterwards observed in the Norwegian Seas by Müller, who figured it in the *Zoologia Danica*. It is still abundant in the East and West of Scotland, and must also have been numerous in the glacial sea.
Sipunculus Bernhardus? Forbes.	The plaster work and loop hole formed in the construction of its dwelling by *Sipunculus* are beautifully preserved in the mouth of *Trophon clathratus* in several specimens.

FORAMINIFERA.

Quinqueloculina seminulum, Linn.

——— ——— *subrotunda*, Montagu.

Spiroloculina planulata, Lamarck.

Biloculina elongata, D'Orb.

Polymorphina lactea, Walker and Jacob.

——————— var. *compressa*, D'Orb.

Truncatulina, lobatula, Walker.

Nonionina depressula, Walker and Jacob.

Polystomella striato-punctata, Fichtel and Moll.

SPONGE.

Cliona celata, Grant.	Common.

ALGÆ.

Melobesia polymorphia,	Common.

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LXXI. Local Unconformity *as shewn in Sections at Bishopbriggs.* By Dr. John Young, *President*, and Mr. John Young.

(Read March 7, 1867.)

PLATE IV.

During the extension of North Coltpark Quarry, Kenmure, near Bishopbriggs, the removal of the upper mass of sandstone, closely adjacent to the railway, revealed a peculiarity of stratification which drew the attention of one of us (Mr. John Young), and has since been the subject of joint investigation.

The appearances presented by the opening in question are shown in the accompanying diagrams. The really horizontal lower rock has been cleared away over a space of about 30 feet square, and is then seen to rest on the denuded edges of vertical, thin-bedded, or flaggy sandstones. On more close inspection, it is found that only a small part of these beds is vertical—that near the north-west corner of the excavation; and that from these beds the others flatten out somewhat rapidly to the south-east, while to the north-west the change of dip is only indicated, the roadway having stopped excavation in this direction. The strike of these beds is at right angles to that of the suprajacent strata. Now these strata are part of the massive sandstone which forms the solid wall of the railway cutting, and is quarried as excellent building material in South Coltpark Quarry. The beds on which it rests are, on the contrary, as already said, thin-bedded. The vertical beds are, in fact, composed each of thin, almost papery layers of sandstone, the whole thickness of each stratum being undulated by the same ripple ridges. These are seen on the surface as well as the ends of the beds, and are true ripple-marks formed during deposit, and having no affinity to those resulting from pressure. As the dip diminishes the beds become thicker; these ripple-marks are less apparent and are confined to one surface of the bed. Again, the thin beds contain a large quantity of carbonaceous matter and fragments of plants, from which the more solid sandstone is, as usual, comparatively free. The contrast of the two sets of strata, both in structure and contents, was thus very marked, and the explanation of this very beautiful example of unconformity became an interesting enquiry.

That the discordance was the result of no dislocation was evident from the outline of the surface presented by the vertical strata, which was smooth, irregularly rounded, and in ground-plan nearly

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circular. We have to do, in fact, with a boss mound, on whose denuded summit another deposit of sandstone has taken place; a thin layer of clay and vegetable matter (converted in places into coal) everywhere intervening between the two rocks, and following the superficial inequalities of the lower. The railway at this point runs some distance below the level of the quarry, but the cutting shows a continuous mass of solid sandstone resting on limestone and shale, but nowhere reveals any beds to which the uptilted ones above could be referred. But what we did see proved that there was considerable inequality in the deposit of the beds, and suggested that the phenomena just described were part of a more general state of things. We therefore resolved to make a careful survey, as time permitted, in the immediate neighbourhood, and especially of the railway cutting.

The section is an ascending one from south to north. It commences about one-third of a mile north of the point where the Helensburgh line branches off, and of an old pit which, at 17 fathoms, struck the Possil ironstone. After walking for a little distance between deep drift and boulder-clay banks, we come to the lowest apparent bed of the section—

4, A thin seam of coal, about 6 inches thick; above it lie
5, Fakes, passing up into
6, Sandstone, about 20 feet of which is seen.

} Dip a few degrees east of north—10°.

A fault crosses the line from north-east to south-west; downthrow to south-east. The beds on the upper side are curiously twisted along the line of fracture. By this fault the true bottom bed of the section has been thrown down southwards. We now start, therefore, again—

1, Massive sandstone; on its irregular upper surface lies
2, Shale, with seams of ironstone; this passes up into
3, Thin fire-clay, supporting
4, A seam of free coal—1 foot thick (?). Above this come
5, Shales containing nodules of ironstone. On the irregular surface of the shales rests
6. Solid sandstone, 20 feet or upwards in thickness.

These beds dip about 8° just north of the fault; the inclination diminishes, till near the first bridge they become approximately horizontal; from this point they undulate slightly with a slowly increasing dip, till about half-way to the next bridge this dip

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becomes more rapid, rising to 10° N.N.W. The proportions of the beds at the same point change. The lower ironstone shale first disappears, the coal coming to rest on the bottom bed of sandstone, which re-appears as a boss at the foot of the cutting. The upper ferruginous bed thins, but does not disappear, swelling out in the irregularities of the sandstone above it. A small fault, parallel in direction and throw, crosses the line less than half-way to the second bridge. At this latter point the sandstone is much broken.

7, Its upper part becomes thin-bedded and fissile; it partly thins out, and is partly cut off by the next two beds.

8, A band of fine black shale containing a thin thread of coal. This shale follows very steadily the next superjacent bed, namely,

9, The Cowglen limestone, which appears at the top of the embankment, just beyond the bridge at Fernbank. It descends at first at an angle of 10°, then of 8°, closely followed by the shale; and, as already said, crosses the bedding of No. 7.

Just below the offices of Fernbank, which overlook the line, the fissile sandstones (which are, however, only the upper part of No. 6) inosculate with and pass into, or become replaced by, a series of shales containing bands of ferruginous, and slightly calcareous sandstone, which diminishes northward in favour of the shales.

10, Over the limestone is a thickness of coarse argillaceous shale with bands of ironstone nodules. Its upper surface is also irregular, and in the hollows lie

11, Patches of a fissile sandstone, whose whole thickness is very inconsiderable. It forms the base of, and passes into,

12, The solid sandstone, which is quarried in South Coltpark Quarry. The lower part of the sandstone is much broken and jointed, and traversed by fakey seams. Eastwards it becomes more regular; its upper part again passing in places into thin layers. This lower rock stretches for some distance along the line at an angle of 10° N.E. Its dressed face shows that its deposition was not continuous nor undisturbed, as many lines occur, indicating that there had been shifting pools during its formation; but there is no sensible admixture of heterogenous substances; no seams of fakey or clayey shales, as at the west end of South Coltpark Quarry. This rock it is which yields the building stone in North Coltpark Quarry, and the removal of which has displayed the anomalous stratification described at the beginning of this paper.

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A bridge connecting the two quarries crosses the line at this point. A little north of this, on the west side of the line, is an opening into the quarry—a splendid mass of sandstone; north, again, from this, near the top of the cutting, limestone and shale overlie the sandstone, and are brought down by a fault parallel to the previous ones, but with a north-east downthrow. Below Coltpark Cottage the limestone and shale are faulted down against the massive sandstone in which Crowhill Quarry is opened.

We do not enter into details concerning the country north and east from this point, as its investigation forms part of a wider one into the systematic position of the Bishopbriggs Sandstone, the results of which we hope at a future time to lay before the Society. At present we would ascertain (1st), What are the beds which now stand vertical beneath the Coltpark Sandstone? and (2nd), How came they into that position?

The sandstone of South Coltpark Quarry is, as has been said, a perfectly continuous deposit—the irregularities of bedding already mentioned, viz., the wavy lines in the cutting, and the patches of clay or shale in the quarry being purely local—whereas the vertical beds are separated from each other by distinct intervals: in other words, each of them is, so far as aspect goes, equivalent to the whole mass of superincumbent sandstone. Moreover, any disturbance which could have so displaced the lower part of that mass must have been somehow apparent in the cutting, which the section shows it is not. The next inferior strata are the argillaceous shales with bands of ironstone in them. These are seen in the cutting, and again at the old tramway to the west of North Coltpark Quarry: between these two points they are lost, as is also the limestone with its subjacent black shale. But it will be remembered that beneath these lay some thickness of thin-bedded sandstones passing down into massive sandstone. It is with these flaggy sandstones that we identify those exposed in the quarry. When reduced to scale, this involves the local absence of about 30 feet of strata.

How have these been removed? Unconformity like this might be produced in one of two ways: either by the forcible elevation subsequent to deposit and consolidation, or at least partial consolidation of lower beds and their insertion among higher ones. This would involve considerable fracture and dislocation, and would necessarily (unless, indeed, it be assumed that the eleva-

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tion occurred while the beds were still very soft) give rise to disturbances to some distance, at least, from the point of violence. That this solution is inapplicable to the present case is manifest from the absence of any such general disturbance: the sequences are perfect, and even at the tramway, where the shales re-appear to the north-west, the dips and strikes are regular. Their absence between the two points indicated must, therefore, be due to a less violent agency.

The second way in which unconformity may arise is by a disturbance prior to the deposit of the upper beds, whose materials are laid down either in a hollow (if the disturbance is one of depression) or around an island, if elevation has been the result. The latter explanation meets the difficulties of the case before us. An elevation of a remarkably local kind, considering the sharpness of the flexure it has produced, has raised an island in the carboniferous sea, denudation has done its work, giving the boss its present rounded form, and has left a further trace in the amorphous layer which separates the two rocks. Around the island have been laid down, first the limestone and its shale, then the argillaceous shale. But those deposited were not continued so long as to overtop the island, or, at least, probably were not, for we shall immediately show reason for doubting how much we know of the original thickness of these beds: suffice it, in the meantime, that the waters which laid down the sand laved a bare boss of rock. Having devised an explanation of the phenomena, it remains to show that our hypothesis is in accordance with other facts.

The first inquiry under this head is whether the assumed elevation required a force whose action would have given rise to other disturbances. In the absence of any displacement affecting several strata, we must presume the force to have been in this instance purely local, and the very remarkable section which the diagram on the wall is an attempt to represent suggests its character. 300 yards to the north-west in Coltmuir Quarry, and 400 to the north in Kenmure Quarry, are two dykes of greenstone, the latter a double one. They do not correspond in direction with each other, and neither would traverse our section; but their discoverer (Mr. J. Young) justly regards them as of very great interest. We can at present merely draw attention to the fact, that at both the sandstone through which they pass has, for a short distance on either side of the dyke, had superinduced on

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it, as a consequence of that intrusion, a horizontally columnar structure, as is rudely suggested in the diagram. Other intrusive rocks occur in the district, and possibly this small island may be the index and the result of some other dyke which has not reached the surface.

This or some other such agent must be looked to as the cause of the very local phenomenon. But there are, besides, irregularities more extensively met with which call for comment, the more so as they diminish the apparently violent effects ascribed to our hypothetical dyke. In describing the section, irregular surfaces of beds have been several times mentioned, and at these points we have examples of upper beds traversing unconformably lower beds. These are (1st), where the massive sandstone (No. 6) crosses the edges of the shales beneath; (2nd), where the black shale and Cowglen Limestone (Nos. 8 and 9) traverse No. 7—that is the upper part of No. 6; and (3rd), where the Coltpark Sandstone (No. 12) traverses the subjacent shale (No. 11). These irregularities all point to one cause, viz., denudation in the intervals of deposit, whether that denudation accompanied slight shiftings of level, or was due merely to the action of another current than that which had determined deposit. Whichever cause is selected (and we are inclined to prefer the former, *i.e.*, slight changes of level), the result is of importance in dealing with the subject of this paper; for the partial erosion visible in the cutting beneath the Coltpark Sandstone indicates the possibility of the displacement not having been so great after all as at first appears, since then the grey shales may have at first had a greater vertical extension than they now exhibit, while, on the other hand, it is quite possible that the elevation may have coincided with a greater thickness of the flaggy sandstones (No. 7), or that elevation may have helped to preserve their original thickness, while the horizontal portion suffered greater denudation prior to the calcareous deposit of the Cowglen Limestone.

Mr. Young has embodied the result of his inquiries into the palæontology of the beds in this cutting in the following summary. In introducing it here, we would only remark that the cement bands spoken of are those found overlying the Coltpark Sandstone between Coltpark and Crowhill quarries, and repeat that their physical geology has not been discussed here, because it will more properly fall in with a future inquiry.

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The following list of fossils is the result of our researches among the strata exposed in the above-mentioned quarries.

1. *Cowglen Limestone.*—This band of limestone, 2½ to 3 feet in thickness, is of a bluish-grey colour when freshly fractured, but weathers into a deep yellow by exposure to the atmosphere. It is compact, and fine-grained in texture; in this locality it has yielded few fossils, and these are not in a very good state of preservation. The most common is *Productus latissimus*, Sow.; some *P. semireticulatus*, Martin; and casts of *Nucula* and *Bellerophon*. This is a good index limestone to the position of the strata; it lies 380 fathoms under the Ell coal of the Lanarkshire field, 50 fathoms above the Possil upper Blackband ironstone, and is found in the above position at Cowglen, near Pollokshaws, Possil, Robroyston, and Kilsyth.

2. *Shale above Limestone.*—This bed of shale immediately overlies the Cowglen Limestone, and is about 20 feet in thickness. It is of a dark-grey colour, and is full of small nodules of impure clay ironstone. In some of the layers of the shale and nodules we find the following species often in a good state of preservation, viz.:—*Goniatites mutabilis*, Phill.; *Pleurotomaria Yvanii*, Lév.; *Macrocheilus imbricatus*, Phill.; *Nucula gibbosa*, Flem.; *N. luciniformis*, Phill.; *Leda attenuatum*, Flem.; *Leda*, sp.; *Myacites*, sp.; *Lingula squamiformis*, Phill.; and *L. mytilloides*, Sow.

3. *Bishopbriggs Sandstone.*—This sandstone overlies the shale, and will average from 40 to 50 feet in thickness in some of the quarries. It is in general of a fine white texture, and has been very extensively quarried in recent years as one of our finest building stones. At the base of the sandstone rock, portions of the trunks of large fossil trees are occasionally found. They belong to *Lepidodendron*, *Knorria*, *Sigillaria*, and roots of *Stigmaria*. Specimens of these plants have been sent to the Hunterian Museum collection. In some of the upper flaggy sandstone of the quarries, tracks and burrows of Arenicolites are common.

4. *Cement Limestone.*—There are two thin bands of this limestone, the lower varying from 9 to 12 inches in thickness, the upper only from 3 to 4 inches, and is separated from the lower by about 6 inches of shale. They lie close upon the sandstone rock, and are overlaid by strata of shale and flaggy sandstone, which are capped by boulder clay and surface soil. The fossils of the Cement Limestone seem to be confined to the thin upper band, the following species being found, viz.:—*Orthoceras sulcatulum*, M'Coy;

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Bellerophon Dumontii, D'Orb.; *B. striatus*, Flem.; *Macrocheilus fusiformis*, Sow; *Murchisonia striatula*, De Kon.; *Dentalium inornatum*, M'Coy; *Edmondia sulcata*, Phill.; *Myacites sulcata*, Flem.; *Nucula gibbosa*, Flem.; *Leda attenuatum*, Flem.; *Axinus deltoideus*, Phill.; *Pinna flabelliformis*, Mart.; *Retzia radialis*, Phill.; and *Streptorhynchus crenistria*, Phill. One interesting fact connected with the mode of occurrence of some of the fossils in this band is, that in nearly every instance the *Edmondia*, *Myacites*, and *Pinna*, are found in their natural erect positions in the limestone, with their valves united, showing that they must have lived and died in the spots where they are now found.

Other instances of local unconformity have been met with in the carboniferous rocks inferior to the Mountain Limestone. They occur, according to the geological surveyors, in the Ayrshire coal-fields, and in the east of Scotland. This kind of irregularity is not unfrequent, due, perhaps, in part, to the rapidity with which different beds in the Calciferous Sandstone series replace each other horizontally, as much as to the nonparallelism of the strata.

Mr. Scott described in the Quart. Journ. Geo. Soc., Lond., an unconformability of the Upper on the Lower Coal Measures of Shropshire. Mr. Jukes, commenting on this, considers it, "*if a case of real unconformability*," a purely local condition, due to contemporaneus erosion and filling up, a process which, he says, "is doubtless *a minor and purely local kind of unconformability*." These two sentences involve less a contradiction than a thorough confusion. The author distinguishes (p. 293) unconformability as the discordance of two sets of beds. Overlap, he limits to the same set of beds, or to different sets of the same conformable series. At p. 299, overlap is further explained as the "extension of one bed or set of beds beyond the original termination of the beds or set of beds below it."

The limitation of overlap to such an extension of upper beyond the lower series—the two retaining, however, their general parallellism—is desirable as an expression for such a series as is found in South Iceland, where, according to Jukes (Origin of River Valleys), the upper so overlap the lower palæozoic rocks. But the distinction of unconformity into two species, the one taking place between beds of the same series, and the other between different series, though easy in the field, yet is one of great difficulty in the classification of strata. For we have no certain

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definition of a bed, none of a series of beds, and Mr. Jukes gives no criterion of the difference of two series of beds. It seems as if the best practical rule were to discriminate series by their organic contents, and to recognise as unconformity the transgressive passage of beds containing one assemblage of organisms across the planes of beds containing a dissimilar series, while local unconformity is only the occurrence of the same results effected by similar processes among beds not distinguishable by any difference of organic contents.

EXPLANATION OF PLATE IV.

Fig. 1. Section along line of railway from near Helensburgh Branch to S. Coltpark Quarry. (Beds numbered as in paper.)

Fig. 2, 3, 4, 5. Sections across line at points *a*, *b*, *c*, *d*, in Fig. 1.

LXXII. GEOLOGICAL NOTES AND QUERIES.

On Quartz Crystals in Limestone.—Some time ago, I picked up, in the Pass of Leny, Perthshire, a small nodule of Encrinal limestone, evidently of carboniferous age. On splitting it open, two cavities containing crystals were observed, which, on further examination, proved to be quartz. The one cavity was round, the other somewhat crescent-shaped, and had evidently been originally occupied by a *Productus*.

The limestone itself contained a little sulphide and sulphate of lime. On placing a few fragments in dilute lydrochloric acid, to remove lime salts, the insoluble residue was found to possess somewhat the appearance of the original pieces, and amounted to 12·92 per cent. It was found to be almost entirely silica. The following is its composition:—

Silica, soluble in solution of Carbonate of Soda, - -	3·86
,, insoluble ,, ,, ,, - -	8·97
Alumina, - - - - - - - - - - -	·12
	12·95

The silica thus appears to occur partly combined and partly in the free state, and seems to have replaced a portion of the carbonate of lime.—*J. Wallace Young, October* 15, 1867.

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Section of Encrinal Limestone near Beith.

Members interested in the study of geological phenomena have at present a fine opportunity of inspecting a tract of Encrinal limestone on the lands of Treehorn, near the town of Beith, Ayrshire. The extension of the line of railway from West Broadstone Quarry into the above lands, for the carriage of the limestone to the iron-works of the district, has necessitated the cutting of a roadway along the side of a small ridge, as an approach to the new quarry. Underneath the surface soil and boulder till, a tract of limestone has been laid bare, about 40 feet in width by 130 in length. The surface of the limestone, which is considerably inclined to the horizon, has been finely polished by glacial action, the striæ running from north-east to south-west, along the inclination of the beds, which dip to the north-east. The boulder till lies in basins of the limestone, which is seen rising to the surface, in many places over the district. Besides the tract of polished limestone referred to, which shows so clearly the results of ice action, the attention of visitors is directed to the organic remains in the strata. These belong principally to the Crinoidea, which, from their very great abundance, form one of the most interesting features of this limestone tract; indeed, in many parts, the rock seems to be almost exclusively made up of their remains. Fragments of stems, one inch in diameter and six to eight inches long, are seen imbedded in the limestone in considerable profusion; and owing to the grinding of the rock surface by the ice, we have sections of these Crinoids displayed in every position, as plainly as we have in polished specimens of Derbyshire Encrinal marble.

This we believe to be one of the finest examples of this kind of marble which we have in the West of Scotland, and as the rock is hard and susceptible of taking a good polish, it could be employed in some of its parts for ornamental purposes.

As the whole of this limestone will be quarried away in the course of a few months, members who may be inclined to visit the district ought to take the earliest opportunity of doing so.—*Robert Craig, Cor. Memb., Langside, Beith, October* 31, 1867.

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PROCEEDINGS FOR THE YEAR 1866-67.

Annual General Meeting, October, 1866.

Edward A. Wünsch, Esq., *Vice-President*, in the Chair.

The minutes of the last meeting, held on April 12, 1866, were read and agreed to.

Mr. James Farie, the Secretary, gave a short verbal report of the progress of the Society during the previous two years, stating that the last printed list of members in 1864, showed a membership of 134, of whom 46 had left the Society, chiefly owing to removals from Glasgow, but that there had been an accession since that date of 4 Life members, 1 Lady member, and 82 Resident members, making the membership now 176, besides 7 Honorary members and Associates and 15 Corresponding members. In conclusion he intimated his resignation of the Secretaryship, owing to his having engaged in business in another part of the country.

The Chairman stated that the present prosperous position of the Society was mainly due to the zealous exertions of Mr. Farie since his election to the Honorary Secretaryship in October, 1864; and for the very efficient manner in which these laborious duties have been discharged, he, (the Chairman) had great pleasure in moving a cordial vote of thanks to Mr. Farie, which, having been seconded by the Rev. Mr. Crosskey, was carried unanimously.

The Treasurer submitted a docqueted statement of the cash account for the year, showing a balance of £27 14s. 8d. in favour of the Society.

The election of officers for the next twelve months was then proceeded with, and scrutineers having been appointed, the result of the ballot was declared to be as follows:—

President—James Smith, Esq., of Jordanhill, F.R.S., F.G.S.

Vice-Presidents—Edward A. Wünsch, Rev. Henry W. Crosskey, John Scouler, M.D., F.L.S.

Secretary—James Macalester,

Treasurer—James Horne.

Librarian and Curator of Museum—James Armstrong.

Council—James Smith, F.R.S., F.G.S., Edward A. Wünsch, Rev. Henry W. Crosskey, John Scouler, M.D., F.L.S., James Macalester, James Horne, James Armstrong, John Young, Thomas Naismith, James Dairon, John Dougall, Fraser Christie, A. Macgregor, John Sutherland, J. Wallace Young, George R. Alexander, Andrew Armour, James Thomson, R. Whyte Skipsey.

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OCTOBER 18, 1867.

EDWARD A. WÜNSCH, ESQ., *Vice-President*, in the Chair.

The Session of the Society was opened this evening, when DAVID PAGE, Esq., LL.D., F.G.S., delivered the annual address on Scottish Geology, its proofs and problems, (p. 252).

NOVEMBER 15, 1866.

REV. HENRY W. CROSSKEY, *Vice-President*, in the Chair.

The following gentlemen were admitted resident members:—John Young, M.D., F.R.S.E., F.G.S., Professor of Natural History, University of Glasgow; William M'Adam, Springfield Works, Dalmarnock; John M'Kenzie, C.E., 4 West Regent Street; W. M. Wilson, writer, 116 St. Vincent Street; John Wight, C.A., Hope Street; Thomas Gilmour, 4 Orchard Street, Partick; J. A. Dixon, writer, 156 West George Street; George M'Pherson, 5 M'Aslan Street; John Robertson, 151 Renfrew Street; James Frame, Union Bank, 113 King Street, Tradeston; James Miller, Dalmarnock Cottage; James F. Stewart, manufacturer, 447 Duke Street; D. Corse Glen, C.E., Greenhead Engine Works; William R. Hutton, chemist, 127 Dundas Street; Rob. Grant, LL.D., F.R.S., Professor of Astronomy in the University of Glasgow; Alex. Strathern, Esq., Sheriff-Substitute of Lanarkshire; Geo. Wink, C.A., 175 West George Street; James Gray, M.D., 15 Newton Terrace; Wm. Taylor, surgeon-dentist, 29 Waterloo Street; Dr. A. Greenlees, 420 Argyll Street; Wm. Rankin, Printer, 37 Jamaica Street; Wm. Wallace, seal engraver, 3 West Nile Street; James Grant, mason, 27 Douglas Street; Samuel Wilson, Eagle Lane, Maxwell Street.

Mr. JOHN YOUNG, in the name of the donor, the Rev. Paton J. Gloag, Blantyre, one of the Society's corresponding members, presented to the museum a set of fossils from the English Oolite and Tertiaries.

Mr. JOHN YOUNG exhibited a specimen of *Crania* (Orbicula?) *trigonalis*, M'Coy, found during the past autumn by the Rev. Paton J. Gloag in the carboniferous limestone of Malahide, near Dublin. After some remarks on the genus *Crania* and its geological range, Mr. Young stated that one other example only of the species exhibited is known to have been found—the type specimen in the collection of Sir R. Griffith, of Dublin, figured and described by M'Coy in his "Synopsis of the Carboniferous Limestone Fossils of Ireland." The one found by Mr. Gloag is somewhat larger than it. Mr. Young had submitted the specimen to Thomas Davidson, Esq., F.R.S., who agreed with him as to its correct identification. The free valve only having yet been discovered, Mr. Davidson has only been able to identify the specimens as belonging doubtfully to *Crania*.

The Rev. H. W. CROSSKEY and Mr. David Robertson exhibited, from the post-glacial beds in the neighbourhood of Paisley, specimens of *Hydrobia ulvæ*, *Margarita Vahlii*, *Rissoa striata*, *Littorina rudis*, *Tellina solidula*, *Cardium edule*, *Modiola modiolus*, *Leda pygmæa*, with the following

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Entomostraca—*Cythere aurantia, C. gibbera, C. pellucida, C. impressa*, and the Foraminifera, *Triloculina oblonga, Polystomella striato-punctata*. The same gentlemen also exhibited from the laminated clay which underlies the glacial bed at Paisley, and has been hitherto deemed unfossiliferous, examples of *Polystomella striato-punctata*.

Mr. CROSSKEY described the results of recent elaborate examinations of the beds in question, which record a series of changes in the climate, the relative distribution of land and water, and the elevation and depression of the earth's surface. By the aid of the microscope, organisms have been discovered in clays before deemed unfossiliferous, and a large number of new species added to previous lists of the fauna of the district. The various steps in the movements of the land during the glacial epoch may be more or less distinctly traced through the varying contents of the successive deposits.

MR. JOHN DOUGALL read a paper on "The Silurian Scenery of the "Enterkin," (p 255).

Mr. JAMES BENNIE read a paper on "Further observations on the Surface Geology of Glasgow,"(p 260).

DECEMBER 6, 1867.

Rev. HENRY W. CROSSKEY, *Vice-President*, in the Chair.

The following gentlemen were elected members:—Mr. Edward Cockey, 38 Burnbank Gardens; Mr. George Muir, 229 High Street; Mr. William Ferguson, F.G.S., 2 St. Aidan's Terrace, Birkenhead; Mr. William Carlisle, 23 West Nile Street; Mr. Alexander M'Kay, slate merchant, Oswald Street; Mr. Daniel M'Kay, slate merchant, Oswald Street; Mr. John Dale, glass Merchant, Oswald Street; Mr. John Small, plumber, Wellington Street; Mr. A. C. Stevenson, Bottleworks, Camlachie; and Dr. William Wallace, F.R.S.E.

Mr. JOHN YOUNG exhibited a slab of shale containing well-preserved plates and scales of *Amphicentrum*, a new genus of carboniferous ganoid fishes recently established by Dr. John Young, for the reception of certain species allied to *Platysomus*, but differing from that genus in the dentition, ornamentation of the scales, and other characters. The specimen exhibited—*A. granulosum*, was from the collection of Mr. Robert Craig, Langside, near Beith, and was discovered by him in the shale under the main limestone of that locality, this being the first notice of its occurrence in the Ayrshire coalfield. Mr. Craig also sent for exhibition a series of teeth of Cestraciont fishes, belonging to the genera *Petalodus, Ctenoptychius, Helodus*, and *Psammodus*, extracted by him from the same shale. Mr. Young remarked that a large crushing tooth, belonging to the last named genus—*P. rugosus Ag.*—was new to our Scottish list of carboniferous fishes, teeth of *Psammodus* being extremely rare in the Scottish carboniferous limestone.

Dr. YOUNG described the peculiar dentition of the genus, and pointed out its functional resemblance to the oral armature of the living Parrot fishes,

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its strong beak-like jaws being such as would enable it to browse, like the Parrot fish, on the coral reefs, among whose remains it occurs in the carboniferous limestones of Beith. He contrasted this type of dentition, and the small oral capacity of *Amphicentrum*, with the large cavity and fine conical teeth of its nearest ally, *Platysomus*, a genus usually considered a vegetable feeder.

The following papers were read:—

1. On some points in the Surface Geology of the Southern Highlands. By Dr. John Young, F.R.S.E. F.G.S., (p. 266).

2. Notes on the Analysis of a Green Fibrous Mineral from Cathkin Quarry. By Mr. J. Wallace Young.—He described it as a hydrated silicate of alumina, iron, and magnesia, and was in his opinion derived from the alteration or decomposition of hornblendic or augitic rocks, (p. 212).

JANUARY 12, 1867.

Rev. HENRY W. CROSSKEY, *Vice-President*, in the Chair.

The following gentlemen were elected resident members:—James Galbraith, Sheriff-Substitute of Lanarkshire; T. Currie Gregory, C.E., F.G.S., St. Vincent Street; Dr. George M'Ewan, 344 St. Vincent Street; Dr. John M'Carron, 13 Bellgrove Street; John Lorimer, merchant, 33 Buchanan Street; Alexander Johnston, writer, 150 St. Vincent Street; Wm. M'Ewan, Slater, 49 Mains Street.

The Chairman and Mr. David Robertson exhibited a series of fossils from the glacial beds at Dalmuir. These beds were first examined and described by the President of the Society, James Smith, Esq. of Jordanhill, but for many years have been overlaid with soil and untouched. The re-discovery of them was a matter of some difficulty, and was only rendered possible through the obliging directions given by the President. More than thirty species exhibited have not previously been found at Dalmuir. Among the more interesting of the species now added to the Dalmuir list are the following:—*Montacuta bidentata, Odostomia spiralis, Mangelia violacea, Margarita Grœnlandica, Trochus helicinus, T. Grœnlandicus, Cylichna obstricta, C. mammillata, Amphisphyra hyalina, A. globosa, Modiolaria discors, Astarte borealis.* For the benefit of future observers, precise directions for the locality, and full lists of species will be given in the Society's Transactions, (p. 267).

The following papers were read:—

1. Notes on some Fossil Crustacea, and a Chilognathous Myriapod from the Coal Measures of the West of Scotland. By Henry Woodward, F.G.S., F.Z.S. of the British Museum. Communicated by the Secretary, (p. 234).

2. On the Sections of Igneous Rocks at the Rye Water, Ayrshire. By R. Whyte Skipsey, (p. 248).

3. On the occurrence of a fault in the Old Red Sandstone and Ballagan series in Dumbuck Glen. By John Young, (p. 257).

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FEBRUARY 7, 1867.

Rev. HENRY W. CROSSKEY, *Vice-President*, in the Chair.

Sir Archibald Alison, Bart., D.C.L., L,L.D., F.R.S.; William Mathison, writer, 49 West George Street; Alexander Mackinlay, 44 West Regent Street; Robert Carrick, 125 Montrose Street; and John Norman, engineer, 32 Grafton Square, were elected resident members. D. R. Rankin, surgeon, Carluke; William Grossart, surgeon, Salsburg, Holytown; Robert Slimon, surgeon, Lesmahagow; and Robert Craig, Langside, Beith, were elected corresponding members—and James Croll, Anderson's University, was elected an honorary associate.

It was remitted to the Chairman and the Secretary to draw up a minute expressive of the great loss which the Society had sustained by the death of the late President, James Smith, Esq., of Jordanhill; and of the value of his scientific labours in the science of Geology, that it might be recorded in the Society's Minute-book; and that the Secretary should transmit a copy of it to Archibald Smith, Esq., of Jordanhill, son of the late President.

The CHAIRMAN delivered an Address on the scientific labours of the late President of the Society, James Smith, Esq., of Jordanhill, (p. 228).

Professor JOHN YOUNG felt certain of the concurrence of the meeting in the suggestion that Mr. Crosskey's eloquent address should form part of the records of the Society. Critical biographies of men who had opened up, or led the way in, new fields of inquiry, are always valuable as contributions to the history of science. But the admirable outline just given of the scientific career of the late Mr. Smith has a special interest to the members of this Society, since the intellectual and moral qualities to which his success was due are therein placed in a clear light. By adopting Mr. Crosskey's address, the Society will record its emphatic answer to the ready detraction which asserts reputations won thirty years ago to have been more easily earned than they would be now. They who speak thus remember only that Mr. Smith was the first to discover; they forget that he was also the first to recognise the bearing and appreciate the value of his discoveries. This it was which, as a later writer well remarks, has made the scene of his labours "classic ground;" this, not accidental priority, is his just title to fame.

Mr. JAMES DAIRON exhibited some specimens of Graptolites, obtained from the lower silurian shales at Dobb's Linn, near Moffat. The series embraced upwards of 15 species belonging to the genera *Graptolithus*, *Diplograpsus*, *Didymograpsus*, and *Rastrites*.

Mr. John Young exhibited a number of specimens of fossil leaves from the Tertiary beds of Ardtun head, in the Island of Mull, obtained last autumn by Mr. Loudon F. M'Lean, a student in Glasgow University. The leaves exhibited, belonging chiefly to the Plane, Buckthorn, and Laurel, some of the species of which are either extinct or do not now exist in these latitudes. Mr. Young described the position of the leaf-beds, and exhibited a piece of Tertiary coal from the same district. He stated that, previous to the announcement of the discovery of these interesting beds by the Duke of

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Argyll in 1851, no strata of the Tertiary period were known to exist in Scotland, and that their discovery had assisted geologists in determining the age of those geat outbursts of trap rock of which many of the Western Isles are composed. The leaf-beds are referred to the Miocene group, and from the fact that they are now covered by great sheets of basalt, representing old lava streams, they clearly prove that intense volcanic action had existed in Scotland, down to so late a period as the close of the Tertiary formation.

Professor YOUNG exhibited a fragment of a jaw (from the Airdrie Blackband), containing several teeth with doubly trenchant margins, like those of *Rhizodus;* but the backward curvature and feeble plication at the base, lent probability to the conjecture that they belonged to a Labyrinthodont, additional specimens of which might perhaps be found in the collections of members of the Society.

Mr J. WALLACE YOUNG read a paper on the "Ballagan Series of Rocks." (p. 209).

MARCH 7, 1867.

EDWARD A. WÜNSCH ESQ., *Vice-President*, in the Chair.

Mr. Walter Graham, ironfounder, 52 New Wynd, and Mr. Thomas Whitelaw, Shields Colliery, Motherwell, were elected resident members.

On the motion of the CHAIRMAN, seconded by the Rev. HENRY W. CROSSKEY, Vice-President, Dr John Young, Professor of Natural History in the University of Glasgow, was elected President of the Society in room of the late James Smith, Esq., of Jordanhill, F.R.S.

Mr. Wünsch then vacated the Chair, which was taken by Professor Young, the newly-elected President.

Dr YOUNG said that he accepted with pride the honour which the Society had conferred on him. He had, though but recently a stranger in Glasgow, received what under other circumstances he might have hoped for as the reward of services rendered. The Society had, as it were, taken him on trust, and he would earnestly endeavour to justify their generous confidence. After alluding to the former school of geology in Scotland, and its influence on the present tendencies of the science, he said it was small gratification to our national pride that Scotchmen were so prominent in England, while in Scotland there exists as yet neither school nor teacher. In the honest work of such a Society as that of Glasgow the means exist for restoring to Scotland somewhat of its former prestige, and he (Dr. Young) was much gratified at the opportunity now offered him of furthering this desirable object. In taking the chair, Dr. Young returned the sincere thanks for the high personal compliment bestowed on himself, and for the tacit appreciation thus shown of the duties in which he was about to enter elsewhere—duties which the Society had indicated its willingness to aid him in discharging, while it had added one more to the ties which drew the University and the city closer together, to the mutual benefit of both.

Mr. JAMES BENNIE exhibited a number of small pebbles and nodules, chiefly of limestone, which he had obtained from a bed of black bituminous

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shale, exposed at various quarries in the East Kilbride; and from the manner in which many of them were covered with holes, so exactly resembling in size, shape, and depth those formed by carnivorous univalves, he suspected the perforations to be due to a similar cause. In some specimens there were two or three holes, others were completely covered, The majority of the specimens were pebbles; others were true nodules, enclosing a coprolitic nucleus. The difficulties which had occured to Mr. Bennie with respect to the borings were, that in the shale in which the stones were found no remains of perforating gasteropods had been met with—the associated fossils being species of *Nucula*, *Orthoceras*, and a Brachiopod—so that he thought it probable they might have been drilled by a worm. The purpose, too, seemed doubtful: if bored in search of food, it afforded an illustration of "instinct at fault;" and he quoted the instance recorded by Woodward, in his "Manual of the Mollusca," of the fossil spine of a sea-urchin which had been drilled by a carnivorous gasteropod. In addition to the holes on the specimens many of them presented a grooved appearance, which he considered might be due to their having been bitten or gnawed by fishes. These pebbles had therefore an interesting geological history. First, they had been consolidated into rock-matter, afterwards rolled into their present form, subjected to the treatment indicated by the perforations and groovings, and, finally, re-deposited. Mr Bennie also exhibited, from the rich fossiliferous shales of the same district, what he considered to be specimens of embryotic crinoids. The most simple of these were formed of a number of hair-like rays, radiating from a minute central orifice; others had stouter rays, with the mouth better marked; while in the more advanced stages the rays had disappeared, and only the body remained, with a hollow in the centre. In this latter form they had much the appearance of a basal root or attachment of a young stalked Encrinite.

Professor YOUNG and Mr. JOHN YOUNG read a joint paper "Local Unconformity, as illustrated in the Carboniferous Rocks near Bishopbriggs," (p. 283).

MARCH 23, 1867.

Professor YOUNG, *President*, in the Chair.

T. Rupert Jones, Professor of Geology, Royal Military College, Sandhurst; James W. Kirkby, Sutherland; Henry Woodward, F.G.S., British Musem; and J. H. M'Chesney, Professor of Geology, University of Chicago, were elected honorary members; and Messrs. Andrew Mackie, M.D., Abbotsford Place; C. B. Aikman, writer, St. Vincent Street; Alex. Smith, Little Hamilton Street, and John Anderson, painter, St. Enoch Square, were elected resident members of the Society.

The President exhibited specimens of a variety of *Megalichthys*, which in Scotland occurs only at Quarter, near Hamilton, and has, he believes, a similarly restricted range in North Staffordshire, which contrasts with the wide distribution of *M. Hibberti*. The scale is not enamelled, and is thickly covered with alternating larger and smaller tubercles, giving a very

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characteristic and elegant ornamentation. He exhibited the scales of genera allied to *Megalichthys*, and pointed out the difficulty of determining genera from single scales, the intermediate varieties between distinct types being numerous. Only a few scales of the Quarter fossil have been found, but further discoveries may justify its erection into a separate genus; meanwhile it is best to retain it as a species.

The following papers were read:—

1. On the Chemistry of some Carboniferous and Old Red Sandstones. By J. Wallace Young, (p. 198).

2. On the Osteology of Fishes. By Dr. John Young, the President.

Dr. Young resumed the subject—the Osteology of Fishes—on which he had previously lectured (14th March). In that lecture he pointed out the arrangement of the facial bones in the osseous and ganoid orders among living fishes, and indicated their homologues, so far as they had been established, in the higher vertebrates. He then described the structure of the head of *Megalichthys*, and comparing it with that of *Polypterus* and *Amia* (two living ganoids found in Egypt and the Southern States of America), explained the close connection which had been established between the former living genus and the extinct family in which *Megalichthys* is included. On the present occasion he briefly summed up the grounds on which *Palæoniscus* and the majority of mesozoic fishes are included in the same family with *Lepidosteus*, the North American ganoid, and referred to the new genus *Calamoichthys* J. A. Smith, as representing, in the absence of the ventral fin, *Platysomus* and its allies. He then showed that the progression which had been asserted as observable among fish from Palæozoic to the present times was not supported by the facts, since there was reason to believe that osseous fishes existed in the old red sandstone, and since the structures just described presented as high a stage of development in ancient as in recent times. He then discussed the forms of the caudal fin, and, illustrating this subject from the researches of Kölliker, Huxley, and others, showed that "homocercal" was a term liable to create confusion, since the majority of osseous fishes are as heterocercal as the sharks. The unequal division of the tail presents several degrees, both in extinct and living ganoids, which might be described as "heteroceral equilobates, or inequilobate." "Diphycercal," M'Coy's term, should be restricted to truly homocercal tails, as of *Cœlacanthus* and *Diplopterus*. The difficulties of classifying fishes were spoken of in reference to the arrangement according to scales, as proposed by Agassiz; and the true principle, that of grouping according to the sum of characters explained.

The Society afterwards adjourned till the 18th current, the concluding meeting of the session.

April 18, 1867.

Professor Young, *President*, in the Chair.

The following papers were read:—

1. On the Entomostraca of the Carboniferous Rocks of Scotland. By

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Professor T. Rupert Jones, F.R.S., and Mr. James W. Kirkby, honorary members of the Society.—Communicated by Mr. Armstrong, (p. 213).

To illustrate this paper, Mr John Young exhibited his interesting collection of mounted specimens of Entomostraca from the carboniferous limestones and shales of the West of Scotland.

2. On the change in the Obliquity of the Ecliptic; its influence on the Climate of the Polar Regions and Level of the sea. By Mr. James Croll, (p. 177). The reading of this long and valuable communication was followed by some observations by the President and the Rev. H. W. Crosskey.

Dr. YOUNG exhibited a new Crustacean from the Upper Silurian rocks of Lesmahagow, which had been kindly lent him by Dr. Slimon. He believed that it belonged to the genus *Hemiaspis*, which Mr. Woodward is at present studying. The specimen is interesting as being the first which has occurred in the Lesmahagow district.

Mr. JAMES THOMSON then exhibited a new genus of Carboniferous Corals, of which beautiful photographs of polished sections were illustrated by the oxyhydrogen light.

Before declaring the session closed, the PRESIDENT congratulated the Society on the number of important papers which had been read during the winter, and on the wide range of subjects which had engaged the attention of members. The Society, since it was founded, had cautiously abstained from rash generalisations; it had, on the contrary, devoted itself to the careful observation of facts; and it had at once rendered the best service to science, and earned for itself a distinctive character by the ready generosity with which its accumulated results in Physical Geology and Palæontology had been placed at the disposal of those who were engaged in special studies. The Transactions of the Society contain the testimony of Davidson, Woodward, Kirkby, and T. Rupert Jones to the success and the liberality of Glasgow collectors; while the records of other societies often show that not a few contributions have been founded on materials derived from the West of Scotland. The only purely theoretical paper of the session, that by Mr Croll, "On the Influence of the Obliquity of the Ecliptic," had been read this evening. Discussion on such an admirable and exhaustive memoir is impossible; but the Society may well be proud that such a memoir will be found in its publications. On questions of Physical Geology, Messrs. Dougal, Skipsey, J. Bryce, L.L.D.; Bennie, J. Young, and J. Young, M.D., had contributed papers referring to the Southern Highlands, the rocks of Ayrshire, of the Kilpatricks, Arran, and of the vicinity of Glasgow. In Chemical Geology, Mr J. Wallace Young has from time to time given us the results of his analysis of rocks from the carboniferous strata, and brought into notice some remarkable peculiarities in their composition. The Palæontological contributions come under three groups—1st, The faunas of different periods have been illustrated by the Rev. H. W. Crosskey in the case of the Glacial beds; by Mr. Young in that of our Limestones; by Mr. Dairon in that of the Southern Silurians. 2d, Descriptions of species and of genera have been given incidentally at nearly all the meetings, and have formed the subject of two very important papers—that by Mr. H.

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Woodward, and that read this evening by Messrs. Jones and Kirkby. 3d, At every meeting, specimens have been shown from he human remains of the Clyde alluvium to the earliest Silurian fossils. The ranges of some species have been shown to be more extended than was formerly supposed, and for others new localities have been announced. The admirably prepared corals of Mr. James Thomson have further indicated, as was seen this evening, that nature-printing can be applied with success in the representation of fossils, and that the lantern can be used to make clear he minutiæ of structure, The enumeration of problems in Scottish geology at the opening of the session was a well-timed reminder of what remains yet to be done. It is from no disregard of Mr. Page's advice that none of the difficulties he spoke of have been attacked ; it only shows that there is a very wide field to go over before the materials for the higher generalisations, such as he alluded to, can be amassed. In conclusion, the President expressed his conviction that the labours of members during the summer would render next winter's session at least as fruitful of instruction as that which had now drawn to a close.

The Society then adjourned till the first Thursday in October.

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DONATIONS TO THE SOCIETY'S LIBRARY,

From October 1, 1866, to September 30, 1867.

1.—Transactions, Journals, and other Publications,

PRESENTED BY THE RESPECTIVE SOCIETIES.

Berlin. Deutsche Geologische Gesellschaft. Zeitschrift, Band xviii., xix., 1, 2 Heft.

Boston. Society of Natural History. Proceedings, Vols. x., xi., Nos. 1—6. Condition and Doings, May, 1866. Memoirs, Vol. i., Parts 1, 2.

Bremen. Abhandlungen Herausgegeben vom Naturwissenschaftlichen Vereine, Band i., Part 1.

Christiania. Royal Norwegian University.

Beskrivelse over *Lophogaster typicus*, af Michael Sars. 4to. 3 plates.

Om *Siphonodentalium vitreum*, af M. Sars. 4to. 3 plates.

Bemærkninger angaaende *Graptolitherne*, af Christian Boeck. 4to. 2 plates.

Om de i Norge Forekommende Fossile Dyrelevninger fra Qvartærperioden, et Bidrag til vor Faunas Historie, af M. Sars. 4to. 4 plates.

Om de Geologiske Forhold paa Kyststrækninger, af Nordre Bergenhus Amt, af M. Irgens og Th. Hortdahl.

Veiviser ved Geologiske Excursioner i Christiania Omegn, af Theodor Kjerulf.

Geologisk Kart over det Sondenfjeldske Norge.

Dresden. Sitzungsberichte der Naturwissenschaftlichen Gesellschaft, Isis. 1860.

Dublin. Royal Geological Society of Ireland. Journal, Vol. i., Part 3.

Edinburgh. Geological Society. Geology and Modern Thought. By David Page.

Gloucester. Cotteswold Naturalists' Field Club. Proceedings, 1865.

Halle. Naturwissenschaftliche Verein fur Sachsen und Thüringen in Halle. Zeitschrift fur die gesammten Naturwissenschaften, Band xxvii., xxviii. 1866.

Liverpool. Geological Society. Proceedings, 1865-66.

London. Geological Society. Quarterly Journal, Vols. xxii., xxiii., Parts 1, 2, 3, 4. List of Fellows.

——— Anthropological Society. Memoirs, Vols. i., ii. — Review and Journal, Nos. 14—19.

Manchester. Geological Society. Transactions, Vol. vi., Parts 1—8.

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Milan. Atti della Societa Italiana di Scienze Naturali. Vol. ix.

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Moscow. Société Impériale des Naturalistes. Bulletin, 1866. No. 1.

Munich. K. Baierische Akademie der Wissenschaften. Sitzungsberichte, 1863-66. 1867, Band i., ii., Part 1.

Newcastle-on-Tyne. Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne. Transactions, Vol. i., Part 2.

Paris. Société Geologique de France. Bulletin, 2e Série. Tome xxiii., No. 4.; Tome xxiv., Nos. 1, 2, 3. List de Membres au Dec. 31, 1866.

Philadelphia. Academy of Sciences. Proceedings, 1866.

Truro. Royal Institution of Cornwall. Journal, Nos. 5—7.

Vienna. K. K. Geologischen Reichsanstalt. Jahrbuch, Band xiii., xiv., xv., xvi., xvii., Nos. 1, 2.—Verhandlungen, 1867. Nos. 1—12.

——— K. K. Zoologisch-Botanische Gesellschaft. Verhandlungen, Band xvi.

Spiridione Brusina. Contribuzione pella Fauna dei Molluschi Dalmati.

Dr. A. Neilreich. Nachträge zur Flora von Nieder-Oesterreich.

Washington. Smithsonian Institution. Report for 1865.

Illustrations of Surface Geology. By Professor E. Hitchcock. 4to. 12 plates.

Palæontology of the Upper Missouri. Invertebrates. By F. B. Meek and F. V. Hayden. 4to. 5 plates.

On the Glacial Drift of the North Western States. By Chas. Whittlesey.

Geological Researches in China, Mongolia, and Japan. By Raphael Pumpelly.

Check List of the Invertebrate Fossils of North America—Cretaceous and Jurassic. By F. B. Meek.

Do. do. Eocene and Oligocene. T. A. Conrad.

Do. do. Miocene. F. B. Meek.

Catalogue of Minerals, with their formulas. By T. Egleston.

II.—Presented by the Authors.

Binney, E. W. On the Upper Coal Measures of England and Scotland.

Croll, James. On the Eccentricity of the Earth's Orbit, and its physical relations to the Glacial Epoch.

——— On the Reason why the difference of reading between a Thermometer exposed to direct sunshine, and one shaded, diminishes as we ascend in the atmosphere.

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Dawson, J. W. The Evidence of Fossil Plants as to the Climate of the Post-Pliocene period in Canada.

Geikie, Archibald. Address to the Geological Section of the British Association at Dundee. Sept., 1867.

Page, David. Geology for General Readers.

Watson, William West. Report upon the Vital, Social, and Economic Statistics of Glasgow for 1866.

Woodward, Henry. On the oldest known British Crab; Notes on the Genus *Eryon;* On a New Genus of Phyllopodous Crustacea from Moffat. 2 plates.

Young, Dr. John. On the affinities of *Platysomus* and allied Genera.

——————— Notice of new genera of Carboniferous Glyptodipterines.

——————— Appendix to Report on the distribution of the Vertebrate Remains from the North Staffordshire Coal-Field.

——————— On the Existence of Glaciers in the high grounds of the South of Scotland.

III.—Miscellaneous.

Annual Report of the Secretary of War for 1866. *From the United States Government.*

Geikie, Archd. On the Chronology of the Trap Rocks of Scotland. 4to. *From Dr. John Young.*

Geologist, The. Vol. for 1843. *From Geo. R. Alexander, Esq.*

Huxley, T. H. Lectures on the Causes of our knowledge of the phenomena of Organic Nature. 1863. *From Jas. Armstrong, Esq.*

Mantell, G. A. Medals of Creation. 1844. *From Dr. Wm. Grossart.*

Parkinson, John. Introduction to the Study of Organic Remains. 1830. *From Dr. Wm. Grossart.*

Ure, John, M.D. A System of Geology. 8vo, 1829. *From Dr. Wm. Grossart.*

The following Books were presented by Archibald Smith, Esq., of Jordanhill, F.R.S., *from the Library of his late father,* James Smith, Esq., of Jordanhill:—

Agassiz, Louis. Catalogue of Books, Tracts, and Memoirs on Zoology and Geology. 4 Vols., 8vo. Ray Society. 1848-54.

D'Archaic, A. Histoire de la Géologie. 1834-53. Tomes ii.—v. 8vo.

Beaudant, F. S. Cours elémentaire d' Histoire Naturelle. n. d.

De la Beche. Geological Observer. 8vo, 1853.

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De la Beche. Report on the Geology of Cornwall, Devon, and West Somerset. 8vo, 1839.

——————— Theoretical Geology. 8vo, 1834.

——————— Geological Manual. 8vo, 1831.

——————— How to observe. Geology. 8vo, 1835.

Bertrand, A. de. Révolutions du Globe. 1845.

Boué, A. Essai Géologique sur l' Ecosse. 8vo, 1820.

Boase, H. S. Primary Geology. 8vo, 1834.

Burrow, Rev. E. I. Elements of Conchology. 8vo, 1815.

Burr, Fred. Introduction to Geology. 8vo, 1836.

Burat, A. Terrains volcaniques de France centrale. 8vo, 1823.

Conybeare, Rev. W. D., & W. Phillips. Geology of England and Wales. 8vo, 1822.

Darwin, Chas. Volcanic Islands. 8vo, 1844.

——————— Cirripedia. 2 Vols. 1851-54.

Daubeny, Charles. Volcanoes. 8vo, 1826.

Desor, E. Excursions dans le glaciers des Alpes. 8vo, 1844-45.

Fairholme, Geo. Mosaic Deluge. 8vo, 1840.

Fleming, Dr. J. Molluscous Animals. 8vo, 1837.

Forbes, E. Malacologia Monensis. 8vo, 1838.

Geological Society of London. Quart. Journ. Vols. i.—xxi., 8vo.

——————— Transactions. 1st Series. 3 Vols., 4to.

——————— ——————— Vol. 3., 4to.

Geological Society of France. Bulletin. Tome xvii.—xxi.

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Greenough, G. B. Principles of Geology. 8vo, 1819.

Humboldt, Alex. von. On Superposition of Rocks. 8vo, 1823.

Huxley, T. H. and R. Etheridge. Catalogue of Fossils in the Museum of Practical Geology. 8vo, 1865.

Jeffreys, J. G. British Conchology. Vols. ii. iii., 8vo.

Johnston, George, M.D. British Zoophytes. 8vo, 1838.

Lecoq, Henri. Glaciers, 8vo, 1847.

——————— Eleméns de Geologie. 2 Vols., 8vo. 1838.

——————— ——————— 1 Vol., 8vo. 1839.

Luc, J. A. de. Physical History of the Globe. 8vo, 1831.

——————— Elementary Treatise on Geology. 8vo, 1809.

Lyell, Sir Charles. Antiquity of Man. 8vo, 1863.

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Macculloch, John, M.D. System of Geology. 2 Vols., 8vo. 1831.

Ormerod, G. W. Index to Transactions and Proceedings of the Geological Society of London, to 1855.

Page, D: Handbook of Geological Terms. 8vo, 1859:

——— The Philosophy of Geology: 1863.

——— Advanced Text Book: 8vo, 1856.

Phillips, John. Palæozoic Fossils: 8vo, 1841.

Raspe, G. E. German Volcanos: 8vo, 1776.

Sacred Geology. Anon. 1847:

Saint-Fond, M. F: de. Minéralogie des Volcans. 8vo, 1784.

School of Mines. Records, Vol. i., Part i. 8vo, 1852.

Scrope, G. P. Volcanoes. 8vo, 1825.

Serres, Marcel de. Geog. des terr. tertiares. 8vo, 1829.

——————— Essai sur les Cavernes a Ossements. 8vo, 1838.

Studer, B. Geologie der Schweiz. 1851.

Ure, A., M.D. New System of Geology. 8vo, 1829.

Woodward, S. P. Manual of the Mollusca. 1851-56.

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Page 76, line 3 from top —for 1865, read *1863.*
— 76, — 16 — botto:n—for Nichol, read *Nicol.*
— 77, — 20 — bottom—for " " "
— 79, — 9 — top —for " " "
— 175, — 2 — top —for Alexandre, read *Alexander.*
— 175, — 2 — top —for Marey, read *Marcey.*
— 217, — 6 — top, 2nd col.—for Bellstone Ironstone, Carluke, read *Bellside Ironstone.*
— 217, — 3 — bottom—for " " "
— 217, — 26 — top, 3rd col.—for Lepidodrendon, read *Lepidodendron.*
— 218, — 3 — top —for upper, read *lower.*
— 218, — 4 — top —read *do. upper do.*
— 218, — 17 — top, 2d col.—for "Gill," read *open-cast.*
— 219, — 2 — bottom, 2d col.—for Hurlet, read *Hamilton.*
— 221, — 11 — top, 2d col.—for Craigenglen, read *Brockley.*
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EXPLANATION OF PLATE II. (page 76.)

BRACHIOPODA FROM TIRFERGUS GLEN, CAMPBELTOWN.

1 *Streptorhynchus crenistria* var *robusta*, Hall: dorsal valve.
1*a* ,, ,, ,, ventral valve.
1*b* ,, ,, ,, side section, showing gibbosity of the ventral valve.
2 *Athyris ambigua*, Sowerby.
2*a* ,, ,, showing faint longitudinal striæ, magnified.
3 *Lingula Thomsonii*, Davidson.
3*a* ,, ,, magnified.
3*b* ,, ,, fragment of the shell, magnified.

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EXPLANATION OF PLATE I. (page 13.)

Fig. 1 *Chiton humilis*, Kirkby: posterior plate, enlarged. Robroyston.
1*a* ,, ,, portion of the surface, magnified.
2 *Chitonellus Youngianus*, Kirkby: plate, enlarged. Craigenglen.
3 *Cypricardia acuticarinata*, Armstrong: left valve, enlarged. Orchard.
3*a* ,, ,, view of both valves.
4 *Cypricardia crebricostata*, Armstrong: left valve, enlarged. Westerhouse.
4*a* ,, ,, view of both valves.
5 *Estheria punctatella*, Jones: carapace valve, natural size. Arden Quarry.
5*a* ,, ,, portion of the surface, magnified.
6 *Nautilus nodiferus*, Armstrong: slightly reduced. Arden Quarry.
7 ,, ,, portion of the outer whorl, with view of channel on the back.
8 *Pleurotomaria Youngiana*, Armstrong: natural size. Craigenglen.

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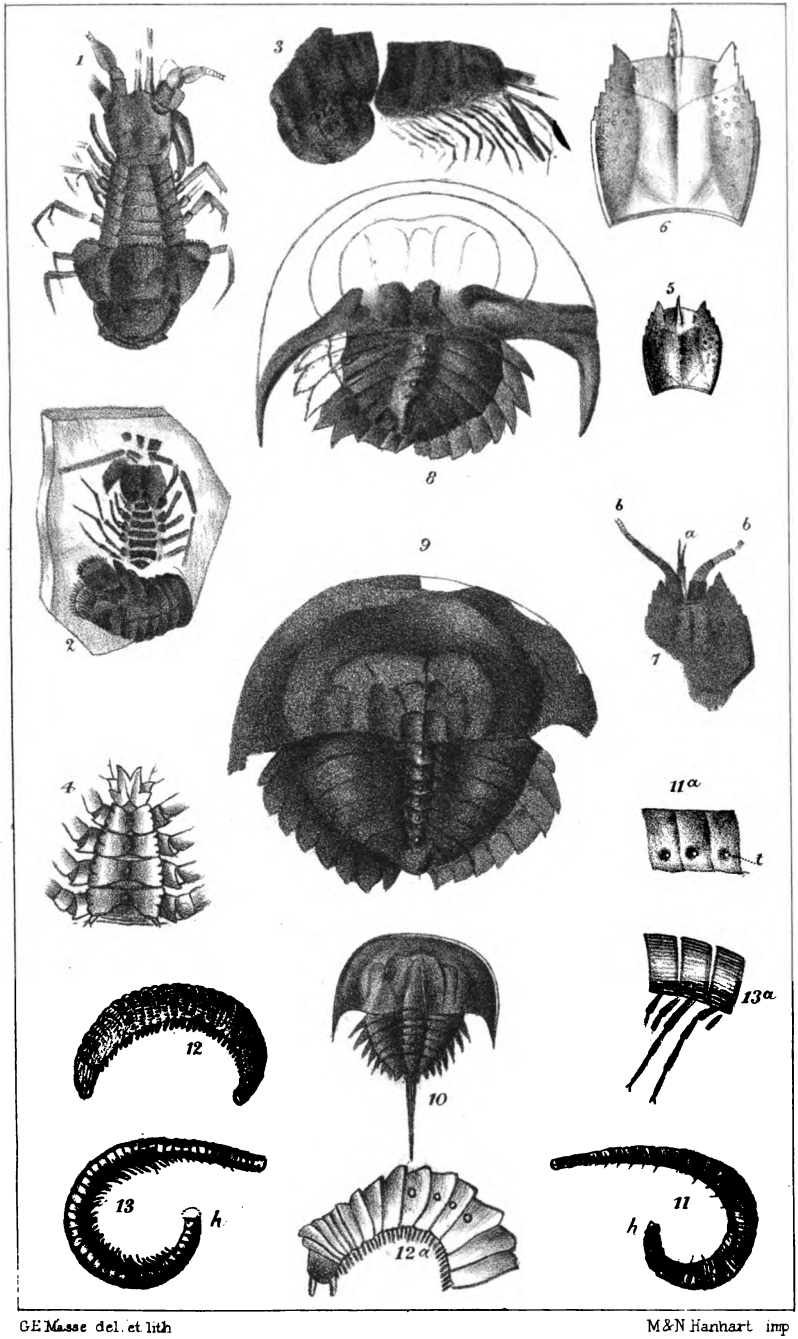

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CRUSTACEA & INSECTA.

From the Coal-measures of Kilmaurs, and other localities.

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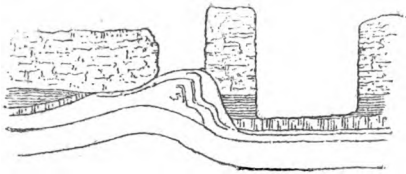

Fig. 4.—Section across "*c*" (fig. 1.)

Fig 5.—Section across "*d*" (fig. 1.)

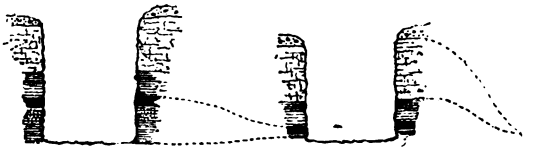

Fig. 2.—Section across "*a*" (fig. 1.) Fig. 3.—Section across "*b*" (fig. 1.)

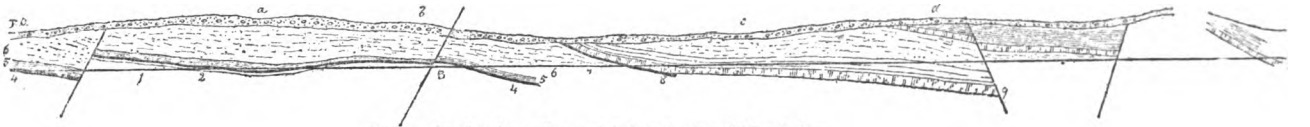

Fig. 1.—Section in Railway at Coltpark, near Bishopbriggs.

Sections to illustrate Paper by Dr. Young and Mr. J. Young, on Local Unconformity, page 283.

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Subscribers' Names will be received by Dr. Young, Mr. James Armstrong, and Mr. John Young, the conductors of the publication; and by Mr. James Macalester, Secretary of the Society, 67 West Nile Street, Glasgow.

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